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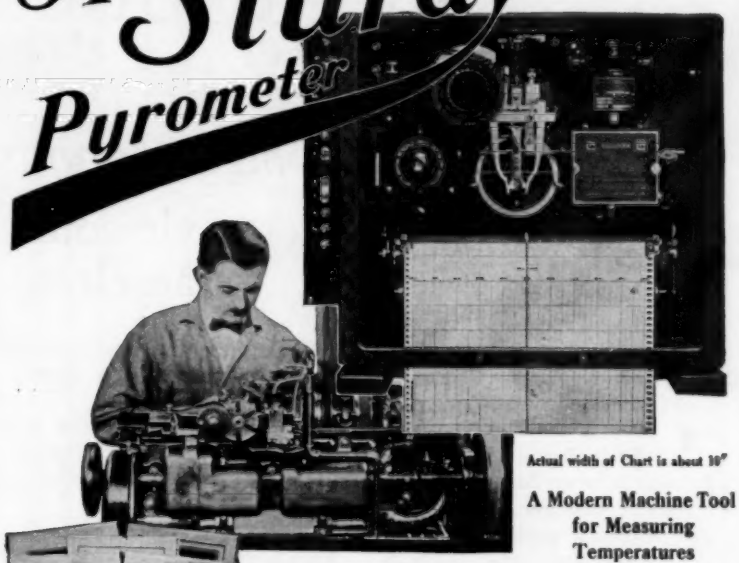

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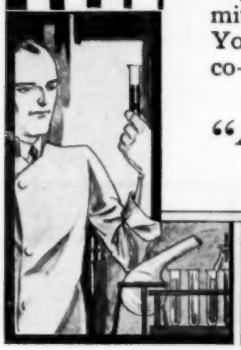

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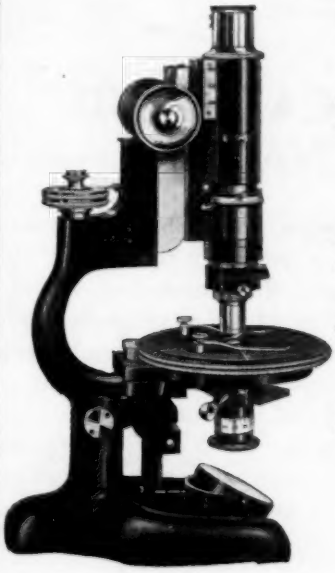

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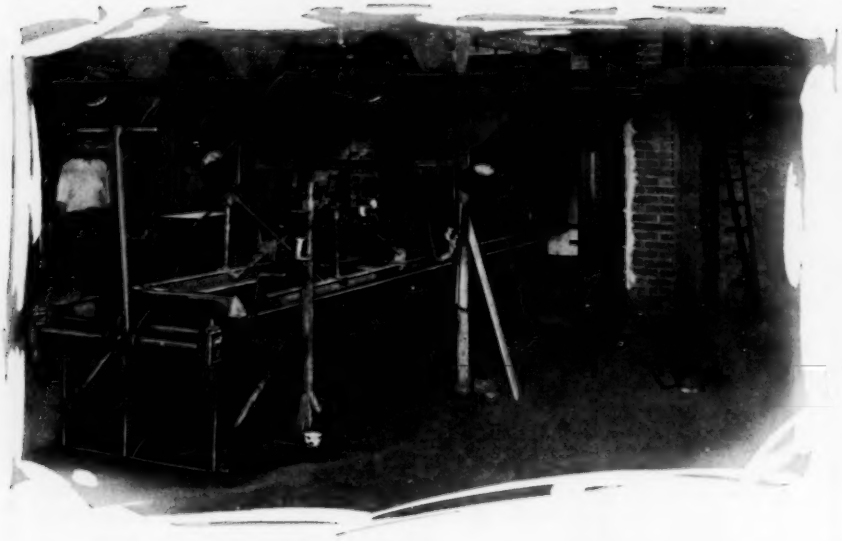

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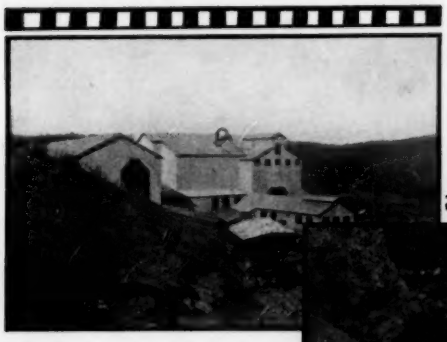

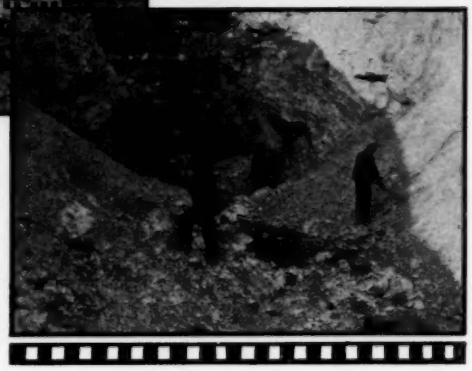

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WET-PROCESS LEADLESS CAST-IRON ENAMELS[1]

By A. I. Andrews and C. H. Commons

ABSTRACT

Several promising compositions have been developed in the laboratory in an extensive investigation for the development of satisfactory leadless wet-process cast-iron enamels. Each series investigated is described. It is concluded that such an enamel is feasible as several fair enamels and one good one were developed during the investigation. Best results were obtained when the enamels were washed and although this is impractical in plant practice it is hoped that an insoluble frit may be obtained thus eliminating the necessity for washing in order to obtain the required gloss.

Introduction

This is a study of the development of satisfactory leadless wet-process cast-iron enamels. Several promising compositions have been developed in the laboratory but none of these have yet been used in plant practice. In the early part of the investigation alumina was not used but it was found to be necessary in the development of good opacity.

Experimental

Weighing All enamel batches were weighed out in 2000-gram lots. The ingredients were ground to pass through a 20-mesh screen, and were thoroughly mixed by screening through a 10-mesh screen and rolling on a sheet of paper for about twenty minutes. All weighings of more than 100 grams were made to the nearest gram; all weighings of less than 100 grams were made to an accuracy of one decigram.

Smelting The frits were smelted in refractory pots heated in gas-fired furnaces large enough for one pot. A new pot was used for each batch; the furnaces were maintained at a temperature of about 1000°C. The frits were smelted until threads pulled from the stirring rod were smooth and free from undissolved particles. The molten frit was then poured into water to quench and shatter it, dried, and dry ground to pass through an 80-mesh sieve. Better results were obtained later by grinding to pass a 100-mesh screen. The frit was ground in small ball mills for one and one-half hours, the fines screened out, and the coarse ground until it passed the screen. The mill batch, composed of the fines and the mill additions, was ground for one-half hour.

The slip was made to the proper consistency. Both dipping and spraying were tried, more consistent results being obtained by spraying.

[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Enamel Division.) This paper is based on data and results obtained by the junior writer to satisfy the thesis requirements for the degree of Bachelor of Science in Ceramic Engineering at the University of Illinois.

Two test pieces, $1\frac{1}{2}$ by 2 and 2 by 4 inches, were cleaned by sandblasting and used soon after cleaning. After enameling they were quickly dried.

The ware was fired in an automatically regulated electric furnace.

Series C1

Titanium oxide substituted for silica has only about one-half the refractory effect of silica; therefore, six batches were prepared in pairs, one member clear, the other having the same composition with addition of 5% of sodium meta-antimonate in the frit. It was hoped that a more fusible enamel than the base would be developed; that the titanium oxide would increase the opacity and gloss; and that by the use of the clear glasses, the results would be comparable with those of Mr. Tetrick.[2] One sample of the original composition and another containing antimony oxide were run as blanks, and as a means of comparing the results.

Results **C1-1:** A glass developed by Mr. Tetrick. The adhesion was good, maturing in ten minutes at 1300°C. The gloss appeared to be good. Pinholes were noticeable. A slight opacity was caused by bubbles.

C1-2: Fairly opaque; good adhesion; matured at 1350°C. The defects were plainly visible when the opacifier was added.

C1-3: Matured at about 1300°F. It had slightly more opacity than Sample C1-1, but in other respects its physical properties were about the same.

C1-4: Matured at same time as Sample C1-3; physical properties about the same as the previous ones, except that it was decidedly yellowish.

C1-5: Same in appearance as the other glasses; matured at a temperature of about 1300°F.

C1-6: Slightly better than the others with respect to gloss and opacity. Adhesion good, and maturing temperature about 1300°. Color, a good white.

Conclusion C1 Series The best of this series was the batch C1-6. This batch contained $2\frac{1}{2}$% of antimony oxide as an opacifier, and a little more than 7% of titanium oxide. It would seem that an addition of titanium oxide was beneficial to the gloss, opacity, and the maturing temperature of the enamel. An amount of titanium oxide greater than about 7% gives an enamel a yellow color which would destroy the commercial value it might have as a white coat. Although C1-6 had a better gloss than the others, it was by no means more serviceable.

The enamels of this series had a good firing range as they did not overfire

[2] Thesis offered as partial requirement for the degree of Bachelor of Science in Ceramic Engineering, Univ. of Illinois.

in twenty minutes. The addition of either titanium oxide or antimony oxide did not appreciably affect the firing range.

The sodium oxide content of the frit was reduced from 22 to 20% to correct the tendency of the surface to pinhole.

TABLE I
SERIES C1

	1	2	3	4	5	6
	(Melted weights)					
Na_2O	23	22.8	22.4	21.9	22.4	22.3
CaF_2	5	4.87	3.5	3.4	3.6	3.5
BaO	5	4.87	5.2	5.1	5.3	5.2
B_2O_3	27	26.4	26.2	25.5	26.7	26.0
Sb_2O_3		2.5		2.6		2.6
SiO_2	40	39.0	27.4	26.7	34.1	33.1
TiO_2			15.3	14.9	7.4	7.2
	(Molal equivalents)					
Na_2O	0.793	0.793	0.793	0.793	0.793	0.793
CaO	0.137	0.137	0.137	0.137	0.137	0.137
BaO	0.075	0.075	0.075	0.075	0.075	0.075
B_2O_3	0.825	0.825	0.825	0.825	0.825	0.825
SiO_2	1.42	1.42	1.00	1.00	1.22	1.22
TiO_2			0.42	0.42	0.20	0.20
Sb_2O_3		0.02		0.02		0.02
	(Batch weights)					
Sodium meta-antimonate		123.3		120.0		122.0
Fluorspar	74.9	64.7	66.3	63.0	67.2	64.0
Barium carbonate	103.6	88.3	90.4	86.0	91.7	87.3
Borax	1100.0	952.0	975.0	928.0	988.5	942.0
Sodium nitrate	102.2	102.8	105.3	100.0	106.8	101.6
Soda ash	219.0	151.3	183.8	150.0	186.5	151.9
Flint	596.4	515.5	372.0	354.0	460.0	438.3
Titanium oxide			208.0	198.0	100.4	95.7
Thermal Expansion (factors by Mayer and Havas)						
	292.2	294.6	344.3	345.8	318.3	324.1

Results of Series C2

Table II contains the data concerning the compositions of these batches.

C2-1: Much improved gloss. Adhesion and color good; somewhat weak in opacity. It was decided to re-mill one-half of this batch with 2% of tin oxide and to call the resulting enamel "C2-6." The surface of C2-6 was fairly smooth; there were few pinholes and no blisters. The surface was still a little too rough to be of any commercial value though it showed a positive improvement over the enamels already developed in this investigation. The enamel matured at 1300°F in twelve minutes, though there seemed to be some advantage in firing it to 1350°F for ten minutes.

C2-2: Test pieces badly blistered. The enamel was too fluid and flowed off the piece almost as soon as it matured. The enamel reacted

with the iron to form black spots varying in size up to about one-quarter of an inch. The enamel matured at about 1250°F in about nine and one-half minutes. When fired to 1350°F, there was very little white showing due to the reaction with the iron. The adhesion remained good, with the gloss neither improved nor impaired.

C2-3: Somewhat better than C2-2 but was of no value except experimentally. Slightly less tendency to blister and discolor than C2-2. Maturing temperature slightly higher; firing range a little longer than the other.

C2-4: Although better than the ones from the previous series, it was not as good as Sample C2-1. Slightly more fluid but otherwise almost the same as the first of this series; the gloss was not quite as good.

C2-5: Not as good a gloss as the rest of this series. The test pieces became glassy at about 1300, but the piece did not mature until 1350° F.

C2-6: Almost the required opacity. Gloss somewhat improved, but otherwise it had the same physical properties as the original.

TABLE II
SERIES C2

	1	2	3	4	5
	(Melted weights)				
Na_2O	20.4	19.5	20.0	19.5	18.8
CaO	3.6	3.4	3.5	6.8	3.3
BaO	5.3	5.1	5.3	5.2	5.0
B_2O_3	26.7	25.8	26.4	25.8	24.8
SiO_2	33.1	32.9	33.8	32.9	31.7
TiO_2	7.4	7.1	7.4	7.2	6.9
Al_2O_3		2.0	0.9		
Sb_2O_3	2.7	2.6	2.7	2.6	2.5
ZnO					7.0
	(Molal equivalents)				
Na_2O	0.700	0.700	0.700	0.700	0.700
CaO	0.137	0.137	0.137	0.137	0.137
BaO	0.075	0.075	0.075	0.075	0.075
B_2O_3	0.825	0.825	0.825	0.825	0.825
SiO_2	1.22	1.22	1.22	1.22	1.22
TiO_2	0.20	0.20	0.20	0.20	0.20
Al_2O_3		0.045	0.020		
Sb_2O_3	0.02	0.02	0.02	0.02	0.02
	(Batch weights)				
Sodium meta-antimonate	129.4	117.8	123.6	122.0	119.6
Fluorspar	67.9	61.8	64.8	120.2	62.8
Barium carbonate	92.6	84.3	89.2	87.3	85.6
Borax	1000.0	908.5	954.9	941.2	924.0
Sodium nitrate	107.8	98.2	103.1	101.7	99.7
Soda ash	98.7	7.5	55.6	93.3	91.5
Flint	465.0	423.0	444.4	438.2	430.0
Titanium oxide	101.5	92.5	97.1	95.7	93.9
Cryolite		148.5	69.2		
Zinc oxide					95.6
Thermal expansion	307.2	304.7	307.6	312.4	294.4

Conclusions C2 Series Since the frit composition C2-1 gave the best enamel thus far, it would seem that a reduction of the sodium oxide content was desirable. It was obvious that an addition of cryolite had an undesirable effect on the enamel. This may have been due to an increase of the fluorine content.

Since an increase of the fluorspar content had very little effect on the properties of the enamel, it seems likely that there was sufficient of this constituent in the original composition.

The addition of zinc oxide was found to be not beneficial to the enamel, and its use was discontinued.

Series C3

In this series the sodium oxide content was reduced from 20% of the melted weight to about 18% and titanium oxide percentage from 7½% to about 6%.

In the previous series, an addition of tin oxide in the mill batch helped the gloss.

Two per cent of tin oxide was added to one part of one batch and 2% of zirconium oxide to another part.

Table III contains the composition data for this series.

Results of Series C3 **C3-1:** Matured at about 1300°F and had a long firing range; was an opaque coating of good colors; no discoloration though there were numerous bubbles near the iron. The surface did not seem to be improved at all.

C3-2: Matured at the same time and temperature as C3-1 and had exactly the same properties.

C3-3: Appeared to be the same as the others of this series, except that it lacked good adhesion. Chipped off fairly easily and left the surface of the metal clean.

C3-4 and C3-5: Had same properties as the others from the same frit. Very slight improvement in the gloss in both cases. Opacity of tin-bearing enamel better than the one containing zirconium oxide.

C3-6: Reduction of the titanium oxide content did not have any appreciable effect on the properties.

Conclusions C3 Series The enamels which were produced in this series were no better than C2-1 of the C2 series. Whiting can be successfully substituted for part of the fluorspar, though nothing is gained by such a substitution. Two per cent of either tin oxide or zirconium oxide increased the gloss slightly.

Titanium oxide can be reduced.

Tin oxide gave much more opacity than the same amount of zirconium oxide.

TABLE III
SERIES C3

	1	2	3	6
	(Melted weights)			
Na_2O	18.5	20.4	18.5	18.6
CaO	3.7	3.6	3.6	3.7
BaO	5.5	5.3	5.5	5.6
B_2O_3	27.3	26.7	27.3	27.8
SiO_2	34.9	33.1	34.9	35.6
TiO_2	7.6	7.4	7.6	5.8
Sb_2O_3	2.8	2.7	2.7	2.8
	(Molal equivalents)			
Na_2O	0.650	0.700	0.650	0.650
CaO	0.137	0.137	0.137	0.137
BaO	0.075	0.075	0.075	0.075
B_2O_3	0.825	0.825	0.825	0.825
SiO_2	1.22	1.22	1.22	1.22
TiO_2	0.20	0.20	0.20	0.15
Sb_2O_3	0.02	0.02	0.02	0.02
	(Batch weights)			
Sodium meta-antimonate	127.0	129.4	127.0	128.5
Sodium nitrate	106.0	107.8	106.0	107.2
Borax	979.0	1000.0	979.0	992.0
Whiting	42.0	43.6		42.8
Fluorspar	33.7	34.0	66.5	34.0
Barium carbonate	92.3	92.6	92.3	93.3
Flint	457.0	465.0	457.0	461.6
Titanium oxide	99.8	101.5	99.8	75.7
Soda ash	65.0	98.7	65.0	65.0
Thermal expansion	291.9	307.2	291.0	305.6

Series C4

Table IV contains the formulas and batch weights for this series.

Results of Series C4

C4-1: Had good adhesion and color. Gloss good and free from pinholes. Opacity slightly weak. Enamel matured at a temperature of 1400°F in twelve minutes. The gloss was the best of any enamel developed during this investigation.

C4-2: Matured at a temperature of about 1300°F in about eleven minutes. Gloss and adhesion good; color bad because of tendency of enamel to react with the iron to form black specks, which could not be removed with any firing procedure.

C4-3: Did not have a good gloss; reacted with iron to form black specks in the surface and crazed badly. It matured at a temperature of 1300°F in twelve minutes.

C4-4: Matured at 1300°F in twelve minutes. The gloss was somewhat better than the gloss of Sample C4-3, though it was still too rough to be of value. There was a greater tendency for the enamel to react with the iron with this composition than with the lesser zinc oxide.

C4-5: Good gloss; good adhesion, and good color. No tendency for iron specks to form, until the enamel was fired to a temperature of more

than 1300°F. The enamel matured at 1200°F in thirteen minutes, but seemed to have a little better surface when fired to 1250°F for twelve minutes. The enamel worked well, but was a little deficient in opacity.

C4-6: Good adhesion and color. The gloss was a little better than the Sample C3–3 from which it was derived. This enamel matured at 1300°F in ten minutes.

Although all the enamels would stand to be fired for twenty minutes at their maturing temperature without harming them, Sample C4-1 was the only one which would stand a temperature much higher than its proper maturing temperature. This sample would safely withstand a temperature of 1550°F without overfiring.

Conclusions on Series C4

The enamel corresponding to C4-1 was the best, but, because it matured at 1400°F it was too hard for service as a wet-process cast-iron enamel.

C4-5 was a good enamel though somewhat deficient in opacity. It had a good gloss free from pinholes. Though it was not a very "high" or brilliant gloss, it was serviceable.

TABLE IV
SERIES C4

	1	2	3	4	5	6
	(Melted weights)					
CaO	10	10	10	10	5.6	3.7
Na_2O	16	20	18	16	22.2	16.0
BaO	5	6	5	5	5.6	5.5
B_2O_3	25	25	25	25	30.0	27.3
Sb_2O_3	5	5	5	5	3.2	2.8
SiO_2	35	30	30	30	28.9	34.9
ZnO			2	5		
TiO_2						7.6
Al_2O_3	4	4	4	4	4.5	
	(Molal equivalents)					
Na_2O	0.563	0.601	0.555	0.488	0.728	0.547
BaO	0.071	0.072	0.063	0.062	0.074	0.075
CaO	0.376	0.327	0.335	0.333	0.198	0.137
B_2O_3	0.771	0.669	0.687	0.681	0.873	0.820
Sb_2O_3	0.036	0.032	0.032	0.032	0.022	0.021
SiO_2	1.245	0.928	0.952	0.944	0.974	1.205
ZnO			0.047	0.115		
TiO_2						0.197
Al_2O_3	0.082	0.072	0.074	0.074	0.088	
	(Batch weights)					
Sodium meta-antimonate	228.2	223.5	224.3	230.4	138.0	139.2
Fluorspar	181.0	174.0	179.0	182.3	93.5	69.6
Barium carbonate	87.1	97.3	85.4	86.5	89.8	96.3
Borax	914.5	875.5	904.0	915.1	1025.0	1017.0
Sodium nitrate	43.5	170.0	105.3	32.5	104.6	105.4
Soda ash					102.7	
Flint	294.5	216.0	223.0	226.2	179.0	471.2
Zinc oxide			26.2	66.5		
Titanium oxide						102.8
Feldspar	252.4	245.0	254.1	261.0	269.0	
Thermal expansion	293.5	332.5	313.7	301.0	297.3	266.9

Series C5

Two frits were made, one of which contained less sodium oxide and slightly more antimony oxide; the other one contained an increased amount of alumina. Each of these frits were made into four enamels differing in their mill additions. The first of each series of four enamels contained no opacifier in the mill; the second contained 3% tin oxide, the third, 6% tin oxide, and the fourth, 5% zirconium oxide.

These enamels were prepared, applied, and fired as usual. The frit compositions, formulas, and batch weights for this series are contained in Table V.

Results of Series C5 There was not much difference in the enamels of this series. They all matured at a temperature of about 1300°F in eleven minutes. The opacity was slightly greater in the samples which did not contain opacifiers in the mill batch than in the previous lots. Those samples which contain tin oxide or zirconium oxide in the mill additions had sufficient opacity. All of the enamels had much less gloss than Sample C4-5, and those which contained 6% tin oxide or 5% zirconium oxide were duller than the others. All were too dull and rough to be serviceable. All of the enamels reacted with the iron to produce black specks in the surface; those with the higher content of opacifier were more active in this respect than the others.

In fairly thin coats, the enamel had good adhesion, but when applied thickly, the enamel would chip off very easily.

TABLE V
SERIES C5

	(Melted weights)		(Molal equivalents)	
	1	5		
Na_2O	18	17.8	0.707	0.703
CaO	5	5.0	0.213	0.216
BaO	5	5.0	0.080	0.081
B_2O_3	27	26.6	0.942	0.937
Sb_2O_3	5	5.0	0.041	0.041
SiO_2	26	25.6	1.051	1.043
Al_2O_3	4	5.0	0.095	0.120
			(Batch weights)	
Sodium meta-antimonate			239.3	242.4
Feldspar			275.1	346.5
Fluorspar			95.0	95.6
Borax			1039.0	1037.0
Sodium nitrate			80.0	57.9
Barium carbonate			91.5	91.5
Flint			181.0	130.4
Thermal expansion			281.5	284.2

Series C6

Series C6 was used to check the results with C4-5, and to improve its opacity and gloss by the addition of tin oxide. The frits were divided

into two parts, one of which had no mill addition of opacity; the other had 2% of tin oxide added to the mill batch.

Results of Series C6

C6-1: Checked C4-5 in all respects, except that it matured at a slightly lower temperature. With careful control of application it was found that the enamel would mature at 1200°F in ten minutes. When fired for nine minutes at a temperature of 1220°F, it gave slightly better results. Although the best temperature seemed to be 1220°F, for nine minutes it fired well at all temperatures up to 1300°F. When fired above this temperature there was a tendency for the enamel to react with the iron and produce black specks on the surface of the ware.

C6-2: Matured exactly as did C6-1. Surface of test pieces somewhat better with the tin oxide in mill bath than without it; opacity sufficient for industrial purposes. Gloss good.

C6S-1: Best enamel produced in this investigation. Opacity and gloss both a little better than the two enamels of series just described. Adhesion very good. Pieces matured under the same conditions as Sample C6-1.

C6S-2: Matured at same time and temperature as rest of series. Opacity not affected by addition of more tin oxide in the mill batch; gloss reduced appreciably.

All enamels adhered well and withstood fall of about fifteen feet onto concrete without chipping.

Although Sample C6S-1 had good gloss, it might be increased if enamel were washed. The surface of the enamel was considerably brightened by the washing. The washed enamel had a great tendency to crawl. It had to be applied so thinly that three coats of the enamel were needed to give the required opacity. It seems that the enamel was only slightly soluble in water, but enough to reduce the gloss slightly. Although it might be possible to use an enamel of this composition when it is washed, it would be likely to give rise to too many difficulties. If the frit had not been ground so fine, this difficulty might not have appeared.

General Conclusions

It is feasible to produce a leadless, wet-process, white cast-iron enamel. Several fair enamels and one good one have been developed.

Those frits which did not have alumina other than cryolite in the composition were too soluble, and tended to give dull surfaces full of pinholes. It was thought that the pinholes were due to an accumulation of the soluble salts leached from the finely-ground frit which concentrate at the surface as the enamel dried.

A METHOD FOR TESTING THE FINENESS OF PORCELAIN ENAMELS[1]

By H. L. Cook

ABSTRACT

The sieve-shaker method of testing is described and recommended for use as a means of testing the fineness of porcelain enamels. The initial expense of equipment is offset by the economy of having the enamels leave the mill room in proper condition.

Introduction

During the past few years, considerable time has been spent by individuals in the enameling industry, developing ways and means of controlling the fineness of milled porcelain enamels. Such activity is the result of a desire toward standardization and technical control of all phases of porcelain enameling. Such standardization and control assures the best workability of porcelain enamels, and the control of the grinding operation is an important factor.

Considering white enamels first, many properties of them are affected by grinding. A better surface, better gloss, more opacity, and better spraying qualities are to be found in very fine enamels. On the other hand, with standard enamels of constant mill charge, crawling and tearing are a result of too fine grinding.

The draining of ground coat enamels is materially affected by the fineness of grinding, and even a slight variance here will give different results in the dip tank. With a constant mill charge using an enamel frit of constant formula, grinding can alter materially the "set-up" action of a ground coat, and therefore its ability to drain properly. The firing of ground coat enamels is also greatly affected by the fineness of grinding, and to have standard firing conditions the fineness of grain of the ground coat enamel must be closely regulated.

Discussion of Other Methods of Screen Analyses

Two methods of using screens to aid in determining fineness employ (1) the use of a cone screen and (2) the use of a flat screen. Both methods are fundamentally the same except, in the first case, the residue is measured, and, in the second case, the residue is weighed. Both methods depend upon using a certain weight or volume of slip, washing the slip through the screen with running water until no more particles go through, and then either weighing or measuring the residue.

It is not the purpose of this paper to deprecate the above methods of enamel fineness analysis, but to present a method employing most of the features of the foregoing and adding a mechanical operation.

[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Enamel Division.)

An enameling plant operation, requiring the use of a number of different men to test mills for their fineness, finds the following objections to either the cone or flat screen methods of testing:

(1) It is difficult for the same man to get results, which really check closely, time after time on the identical enamel slip.

(2) It is still more difficult to get a number of men to use the same technique, and thereby get check results. The term "until no more particles go through the screen," leaves that very important part of the screen analysis up to individual judgment.

(3) These methods seem more inaccurate to the outsider than they really are, for varying time of washing, water pressure, and manipulation suggest errors.

Sieve-Shaker Method of Testing

Since pressure to find some other method of mill testing was constantly exerted, and mechanical shaking seemed more desirable, the use of a Tyler Rotap screen shaker suggested itself.

Using this mechanical shaker, the following method of screen analysis was formulated: 260 cubic centimeters of enamel slip are drawn from the mill and weighed so that a standard specific gravity, hence a standard water content, is assured. This slip is washed through a 40 screen and then through a fine screen with a gentle stream of water until most of the finer particles are washed through. The residue is allowed to dry on the screen, and before the screen is placed in the sieve shaker, an inspection must prove that the residue is dry and sandy. In other words, the residue can not be caked. The screen is allowed to shake in the Rotap sieve shaker for 7 minutes. The residue then retained on the screen is weighed on a balance accurate to grams. The fineness of the mill is expressed as the number of grams remaining on the screen.

In shaking a screen, the Rotap screen shaker imparts a rapid shaking of a screen in a horizontal plane. At the same time, a heavy hammer taps the screen holding device at regular intervals of time. Such a machine assures a definite mechanical method of shaking.

The first item to consider was the time of shaking the screen. Preliminary tests proved that at the end of seven minutes, the residue would reach a constant weight.

Using this as a standard time, the next item considered was the accuracy of the test. Six tests were run on a constant enamel slip, endeavoring to keep the variable of washing as constant as possible. These six determinations checked within one gram. Another man was taught the general procedure of the test, and he ran three determinations on the same enamel slip, and his results checked the first six results by one gram. Later on, five men ran tests using a constant enamel slip, and all weights checked

within one gram. As many as seven men now make these screen analyses, and usually their results can be checked within one gram by some other man.

The time of shaking was taken up again, and further tests proved that all particles finer than the mesh of the screen would go through in a time of seven minutes. Using a constant slip, identical weights were obtained when the sieve shaker was allowed to run ten, thirteen, sixteen, and nineteen minutes.

The washing of the enamel slip was next considered. Using a constant enamel, samples were washed gently, and then with increasing pressure and thoroughness. In every instance, the residue on the screen was the same after the screen had been run on the sieve shaker. It is necessary, however, that the washing be thorough enough to remove all fine particles, all clay and soluble salts, otherwise the residue will cake while drying.

Variation in the water content in different mill loads was considered as a source of error, and it was necessary to formulate a table which we could use when the enamel did not have the specific gravity allowed by the procedure of the test. The standard specific gravity used is 1.86. The specific gravity of a constant enamel slip was varied down to 1.77. It was found that if a mill tests 13 grams at 1.86, it will test 10 grams at 1.77. When we consider white enamels, for example, the following table is used:

Specific gravity	Add to weight of residue
1.86	Standard
1.83	1 gram
1.80	2 grams
1.77	3 grams

Another variable in this method of testing is the test screens themselves. It was found that after a screen is used to make a number of determinations, the openings in the screen become partially filled, and the tautness of the screen is lessened. Running check determinations, using one older screen which had been used for quite a number of determinations, and two new screens, it was found that the new screens gave check results but the older screen retained a heavier residue. Many times, the openings in an older screen will look no more filled than those of a newer screen, but check results cannot be obtained. The reason for this is not clear, unless the tautness of the screen enters into the shaking action. The fact remains, however, that after a screen has been used for some time, it will retain a greater residue. By running comparative tests once or twice a week, old screens may be calibrated against new screens, and used for still many more determinations.

The proper mesh screen to use for testing the fineness of various enamels, depends entirely upon how finely they are ground. It is better, however, not to use a screen giving too small a residue, or one giving too great a

residue. A residue between ten and twenty grams makes an easy residue with which to work.

The speed with which this method of testing can be run depends largely upon a hot drier and the volume of residue to dry. Under good working conditions, the test can be run in a time of twenty to thirty minutes.

A criticism of the method may be the expense of equipment. Naturally, this is an item, but it is far more economical to have enamels leave the mill room absolutely correct, than to waste valuable time doctoring enamels on the production floor.

Advantages of the Sieve-Shaker Method of Testing

The following seem to be advantages of the sieve-shaker method of testing:

(1) All shaking action on the screen is mechanical. It is generally accepted that correct screen tests can only be obtained by mechanical means.

(2) It is possible to get check results from a number of mill testing employees. Where a mill room must run continuously, and it is desirable to have two or more men on each shift able to test mills, this method of testing is more or less essential.

(3) This method of testing has a psychological effect on all co-working employees in the shop. It establishes confidence in the enamels since their delivery is uniform due to uniformity of grinding. The tester, himself, becomes more accurate when he knows he can be readily checked at any time. This method obtains the confidence of management and allows for peace of mind, since factors not quite controlled are always vexing.

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DAYTON, OHIO

LEPIDOLITE IN CONE 6 TERRA COTTA GLAZES[1]

By Harry E. Davis

ABSTRACT

The following study was undertaken to discover what possibilities might lie in the introduction of Li_2O into the RO of a terra cotta glaze, using lepidolite.

Introduction

Until the work of Robert Twells,[2] Research Dept., General Electric Co., practically nothing on the subject had appeared in the literature of the American Ceramic Society. Mr. Twells, working with porcelain body mixtures, found lepidolite to be valuable in increasing resistance to thermal shocks, due to a lowering of the coefficient of expansion. Its fusion progressing slowly similar to feldspar, it is further to be assumed that it would tend to increase the firing range of a glaze or body composition.

In an article on "Lithium, Caesium and Rubidium,"[3] Dr. Kenneth K. Landes mentions the use of lepidolite in glass, resulting in a lowered coefficient of expansion, and a harder surface on finished glass, which would retain its luster in moist air.

Experimental Work

Li_2O in increasing amounts was introduced into a standard glaze formula, already quite satisfactory. Lepidolite being a very complex compound, it was assumed for this work to have the formula:

$$Li_2O \cdot Al_2O_3(F \cdot OH)_2 \cdot 3SiO_2$$

with a molecular and combining weight of 383. Li_2O was in all cases substituted for feldspar, and the following table gives the molecular formulas of the glazes used, No. 0 being the base glaze and Nos. 1 to 5 having lepidolite added in increments of 0.02 equivalents.

	No. 0	1	2	3	4	5
KNaO	0.277	0.257	0.237	0.217	0.197	0.177
Li_2O	0.000	0.020	0.040	0.060	0.080	0.100
CaO	0.288	0.020	0.040	0.060	0.080	0.100
ZnO	0.145	0.020	0.040	0.060	0.080	0.100
MgO	0.100	0.020	0.040	0.060	0.080	0.100
BaO	0.190	0.020	0.040	0.060	0.080	0.100
Al_2O_3	0.350	0.020	0.040	0.060	0.080	0.100
SiO_2	2.710	0.020	0.040	0.060	0.080	0.100

	Batch weights					
	No. 0	1	2	3	4	5
Maine feldspar	498	462	426	390	354	318
Lepidolite		25	49	74	99	123
Whiting	94	94	94	94	94	94

[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Terra Cotta Division.)

[2] "Lepidolite in a Porcelain Body," *Jour. Amer. Ceram. Soc.*, **11** [8], 644–48 (1928).

[3] "Lithium, Caesium, Rubidium," *Foote-Prints*, Vol. 1, No. 3 (1928).

	Batch weights					
	No. 0	1	2	3	4	5
Calcined ZnO	38	38	38	38	38	38
Steatite	40	40	40	40	40	40
Barium	121	121	121	121	121	121
Ball clay	60	60	60	60	60	60
Flint	149	160	172	183	194	206
	1000	1000	1000	1000	1000	1000
Opax	70	70	70	70	70	70

The above glazes were sprayed on 3- by 6-inch samples and fired between cones 6 and 7 in a large commercial terra cotta kiln in approximately 120 hours. All were tested in an autoclave, using No. 0 as a comparison sample each time.

Results

Autoclave Tests It is very difficult to arrive at any definite conclusions from this preliminary work.

Of the 5 specimens of No. 0 tested with each of the lepidolite glazes, 3 crazed, and 2 did not. The crazing was very coarse meshed, five distinct cracks in 18 sq. in. being the maximum.

Nos. 1 and 3 showed one small craze line.

Nos. 2 and 5 showed 3 lines.

No. 4 one very small crack.

It is worth noting that these cracks are so fine as to be scarcely distinguishable after washing with ink, whereas those in No. 0 show very plainly after similar treatment.

Surface of Glaze Starting with a satin mat enamel there is very little change in the surface appearance of the glaze with increasing Li_2O except perhaps a slight softening which adds somewhat to the already pleasing texture. The opacity and whiteness remain practically the same for a given thickness of application. The results do not therefore check the work of Mr. Twells, since he finds that the molecular replacement of K_2O by Li_2O greatly increases the vitrification temperature of the body.

Conclusions

Compared with a glaze already low in its coefficient of expansion, it is questionable whether or not the introduction of lepidolite will improve a glaze in this respect, but it is very obvious that its effect is in no wise detrimental. It does add to the beauty of the glaze surface, and when considered as a glaze material only, a cost of approximately $60.00 a ton is not at all prohibitive. It is believed that further experiments will place this little used mineral on the regular list of glaze ingredients.

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SPECIAL DEPTH GAGE FOR MEASUREMENT AND CONTROL OF CERAMIC COATINGS[1]

By A. Lee Bennett

ABSTRACT

A depth gage is described whereby the thickness of ceramic coatings on any piece of ware may be determined regardless of its shape or surface.

Introduction

There are usually a number of reasons for desiring the very close control of the thickness of a ceramic coating. If for no other reason than economy of materials, precise regulation is desirable. With practically every ceramic product, however, other and considerably more important reasons may be found. Such defects as crawling, pinholing, bubbling or blistering, crazing, etc., as well as the final color and texture of the finish, are usually influenced by the thickness at which it is applied to the ware. In fact, in some cases the thickness of application of the finish used is the most important factor to be considered in preventing defects such as those just enumerated.

General Methods

Numerous methods intended to control the thickness of coatings are in every-day use. Many of them depend on the uniformity of body, ceramic finish, and method of application.

Such control, through complete standardization, is nearly always no more precise than the least accurate of the processes which are used. If, however, a very high degree of exactness can be maintained constantly throughout each of the processes involved in the preparation and application of a ceramic finish, no further checking of the thickness of coat obtained is necessary under any ordinary conditions. It is usually the case, however, that the manufacturing processes cannot be kept sufficiently uniform as to avoid variations in thickness which are too large to be ignored. Under such circumstances the logical thing to do is to estimate or measure the thickness of coating which is being obtained in actual practice. Compensation may then be made for any variations affecting the thickness of coat which have occurred in the processes involved in the preparation of body or finish.

The number of methods in regular use for measuring the thickness of coatings is undoubtedly large. They may be classed generally as direct or indirect processes.

Indirect Methods

Probably the best example of indirect measurement is that of weighing the product before applying the coating and comparing the relative in-

[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Terra Cotta Division.)

crease in weight with a standard relationship which has been established as satisfactory.

Direct Methods

While such indirect processes probably meet the control requirements of a number of small products very nicely, it is our opinion that direct methods of measurement must be regarded as superior. The direct methods give a clearer picture of what we are actually interested in, they are faster, and even in the case of certain small products, probably a little more reliable than the usual methods of indirect measurement.

FIG. 1.

Perhaps the simplest form of direct measurement of a ceramic coating is that of cutting down through the finish after it has been applied, using a knife or other sharp instrument and scraping a portion of the material away from one side of the cut. By comparison with known standards it is possible for a skilled operator to estimate the thickness obtained in a fairly accurate manner. It is obvious, however, that such a measurement depends largely on the judgment of the operator, and so cannot be recommended. The fact that exact records cannot be kept is another obvious disadvantage.

Through the use of a special depth gage it is possible to obtain direct visual measurement. With the usual ceramic products it is not at all difficult to definitely standardize the methods of using the depth gage. It is then possible to obtain thickness readings which are practically as precise as the gage itself.

FIG. 2.

The particular form of depth gage recommended is one which has been developed from a standard type of machinist's instrument having a precision of 0.001 inch. It has a total range of 0.2 inch with the dial representing 0.1 inch, graduated into 100 parts, each, of course, representing 0.001 inch. The gage is equipped with three contact points which are interchangeable. We use contact point *D* for most purposes, especially flat surfaces and

have found contact point C well suited for use on certain curved surfaces. These contact points are shown in Fig. 3.

Special bases have been made for the gage, one for use on certain curved surfaces and the other for flat or nearly flat surfaces. Figure 1 shows the unmounted gage and Fig. 2 shows the gage prepared for use on certain curved and flat surfaces. The gage shown on the left is that used for curved surfaces, principally roofing tile and that on the right is used for flat surfaces, such as terra cotta or wall tile. Figure 3 gives the exact dimensions of the gage and the special bases which were shown in Fig. 2.

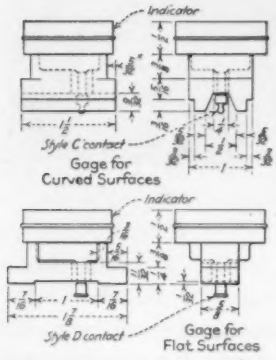

FIG. 3.—Special depth gages, using Starrett Universal Dial Test Indicator, No. 196. Graduated $^1/_{1000}$ inch. Contact points of style as noted.

Methods of Use

With the exception of those products which have perfectly plane surfaces, the first step in using the depth gage is to place it on the surface of the ware, as soon as the coating applied has dried sufficiently so that it will not be compressed or flow under the weight of the gage or will not stick to its surfaces, and take a reading at the proposed point of measurement. On ware, the surfaces of which are very nearly uniform, it is usually possible to obtain a perfect zero setting of the gage by simply moving it a small distance if necessary. Where the unevenness of the coated surface is such that too much time would be consumed in finding a point of zero reading at which to make the desired thickness measurement, the reading of the gage may be noted, keeping in mind whether it indicates a positive or a negative correction. This correction can then be made mentally as soon as the thickness reading is made.

Except for the perfect surfaces previously mentioned, the gage must, of course, be set in the same position for the actual depth reading as that used in determining the "zero" reading. This may be accomplished by carefully tipping the gage on one edge of its base, which is not moved from its original position, as illustrated in Fig. 4, or, by marking the position of the base on the surface of the coating, using a soft lead pencil as shown in Fig. 5.

In either case, the next step in the operation is to scrape away the coating carefully over an area approximately $^3/_8$ inch square, so that the plunger of the gage will now come in contact with what was the original surface of the ware before the coating was applied. With such products as have not been previously hardened or biscuited, care must be exercised so that none of the original surface is scraped away.

Upon replacing the depth gage in its original position and making, mentally, whatever correction is necessary, the thickness of the applied coating is obtained directly in thousandths of an inch.

FIG. 4.

From our observations over a period of several years, we believe that for practically all products, the depth gage described in this article will, when properly used, give accurate measurements of the thickness of surface

FIG. 5.

coatings precise to within 0.002 inch. The thickness of some coatings can, with a properly standardized method of using the depth gage, be regularly determined within 0.001 inch.

Special Problems

Some products, such as architectural terra cotta, are frequently produced with rough textured surfaces. Obviously it is practically impossible to read directly the thickness of coatings applied on such very irregular surfaces. Usually there are some smooth surfaces, used in conjunction with the textured ones, on which the thickness of the coating may be read. In all other cases it has been found practical to coat smooth sample pieces along with and in identically the same manner as the textured ware and then make the desired thickness measurements on them. Readings obtained in this manner will not indicate such variations in thickness of coating as may be obtained on the textured ware because of its different surface. They do, however, give an indication of the average thickness being obtained, by means of which the control of the process of application can be easily effected.

One other special problem in the measurement of the thickness of ceramic coatings is presented by those coatings which are splashed or spotted onto the surface of the ware in such a manner that by their very nature they vary in thickness. Most of such finishes, however, are applied with as much uniformity as possible and with all of these a system of control can usually be developed which is based on the allowable thickness range from minimum to maximum and the method of obtaining such extreme thickness readings may be specified.

Various other problems may be expected to arise in adapting the depth gage for use in controlling the thickness of coatings used on various other products. Because of its flexibility, the gage should lend itself readily for use in the majority of cases.

Summary

We have found the depth gage described to be one of the principal factors in standardizing methods of application for terra cotta, roofing tile, pottery, and floor or wall tile coatings. In fact, they are at present regarded as an invaluable aid in our work and our processes are standardized on a basis of their direct readings. We wish to recommend their use in the standardization of the processes of application of ceramic coatings for the above-mentioned or similar products.

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NOTES ON TERRA COTTA GLAZE CONSISTENCY[1]

By H. Spurrier

ABSTRACT

Some of the difficulties encountered in applying glaze to terra cotta are discussed. The use of a hydrometer to test glazes is misleading as a hydrometer supplies gravity indication only in true solutions and glazes are not true solutions; furthermore the viscosity of a glaze may obscure the real specific gravity. It is suggested that in order to control a glaze it should first be made to a desirable specific gravity and then the desired viscosity at that gravity be ascertained by experiment. A viscosimeter and specific gravity bottle are suggested for this purpose. The effect of change of alkalinity and of bacteria together with the control of glaze wastage are also discussed.

Introduction

The application of glaze to terra cotta is fraught with many difficulties, for some of which it is seemingly difficult to assign a definite cause. Of this character are those difficulties which arise from the variations in the consistency of the glaze. Where uniformity is of considerable importance these variations seriously affect the practice of spray glazing, because of differences in the flow of glaze from the spray nozzles.

Hydrometer Testing

The reprehensible practice of testing glazes with the hydrometer is still quite common, and is probably only persisted in because it is easy, but it is also excessively misleading.

The function of the hydrometer is to supply indications of specific gravity and such indications may be read in terms of many scales, Baumé being the usual method. There is also a modification called a "glueometer."

No matter what scale is used the function of the hydrometer is to supply gravity indications only in true solutions, and glazes are not true solutions; they are so far from this that only in a very restricted sense is there any solution at all. They are really two-phase mixtures of solids and liquids.

It is sometimes claimed that though the hydrometer does not give accurate readings in a glaze, it, nevertheless, furnishes "useful indications." Such a contention is entirely abortive.

A certain terra cotta glaze was prepared for use in the customary way, and gave a hydrometer reading of 74°Bé, which corresponds to a specific gravity of 2.04. The gravity was also taken by weighing and showed 1.856. This is a difference of 10.99% on the basis of the 2.04 reading, representing 100.

[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Terra Cotta Division.)

Influence of Viscosity The difference noted between the hydrometer reading and the specific gravity obtained by weighing is not a gravity difference at all, as in each case the real gravity was the same, but in the case of the hydrometer, the real gravity was obscured by the influence of the viscous character of the glaze.

Unfortunately in using the hydrometer there is nothing to show whether variations in glazes are due to differences in specific gravity or viscosity, or both, or what viscosity corresponds in specific gravity difference. This is well brought out by readings; on the glaze cited above, taken 20 hours later, which gave (after appropriate agitation) 68°Bé equal to a gravity of 1.875, whereas the real gravity had not changed at all.

While it is obvious that the changes that take place in a glaze do affect the hydrometer, it is also true that the hydrometer is not capable of measuring those changes in terms of specific gravity. The recognition of these facts is fundamental if uniform spray glazing is to be approached.

A spray nozzle is very sensitive to variations in viscosity of the glaze passing, not only on account of the viscosity considered alone, but also on account of the protective influence afforded by the clay upon the sharp angular frit, and very great disturbances are occasioned in this way.

A clear understanding of what takes place in a glaze after being freshly made will go a long way toward its intelligent control.

Effect of Change in Alkalinity The mixture of frit, clay, water, and dextrine, or tragacanth, usually constituting the terra cotta glaze, after due mixing, begins at once to suffer change due to hydrolysis and a slight degree of alkalinity sets in increasing with time, up to a definite limit for a particular glaze; this change, though slight, is quite enough to produce deflocculation with a pronounced thinning out of the mixture.

After this change, or even before its completion, another change commences, and of an entirely opposite character.

Effect of Bacteria Both the clay and gum constituents set up bacterial action, which may become very pronounced, and it would be surprising if this did not occur, as it is well known that a single gram of soil may harbor millions of bacteria.

There are many kinds of bacteria, and among those that have to do with the fermentation of gums, are included members of the family zoöglœa, so called because they provide a gelatinous envelope for themselves. An excellent example of such bacteria is found in "mother" of vinegar, which is nothing more than a B/E thaceticus with its zoöglœal jelly.

The zoöglœal jelly consists very largely of water, which is secured at the expense of the already limited supply in the glaze, and this is one cause for the thickening or increased viscosity; but our bacteria are acid forming to the extent that they entirely overcome the slight initial alkalinity, the

consequence being that a pronounced flocculation sets in and the two above noted causes, together, produce very considerable thickening.

A specific example will illustrate the foregoing:

The viscosities were secured from a simple flow viscometer giving 13.4 seconds for 200 cc. of water.

Glaze made	Nov. 19	viscosity	18.0	sec.	being	1.344	that	of	water
Tested	Dec. 4	"	18.4	"	"	1.373	"	"	"
"	Dec. 15	"	25.2	"	"	1.880	"	"	"
"	Dec. 19	"	27.6	"	"	2.060	"	"	"
"	Dec. 28	"	24.4	"	"	1.810	"	"	"

During these changes there was no variation in specific gravity taken by actual weighing. The December 19 reading marks the zenith of the bacterial action, the food supply evidently having been exhausted.

Further action is still possible by reason of the growth of algae, which sometimes occurs and progresses sufficiently to make the glaze again thicken up, sometimes to assume color, generate carbon dioxide and carbon monoxide gas in quite liberal quantities, and to assume a foul odor principally of sulphuretted hydrogen, which arises from the small sulphur content of the decomposing vegetable albumen.

Method of Control

In order to completely control a glaze for spraying purposes, it should first be made up to a desirable specific gravity and then the desired viscosity at that gravity should be ascertained by experiment once for all. Having once done this the viscosity should be maintained constant preferably by the use of sulphur dioxide gas on the one hand, or an alkali on the other. In this way it has been found quite easy to maintain the physical conditions of the glaze within narrow limits.

Viscosimeter A quite arbitrary viscosimeter standardized on an accurately reproducible standard such as a sugar solution serves very well indeed.

Specific Gravity Bottle The most convenient method of taking the specific gravity is to cut off a deciliter flask and grind the top until it holds 100 grams of water at the specified temperature. A small glass plate serves as a cover, a brass counterpoise for the flask, and cover is convenient.

Obviously the specific gravity determination resolves itself into merely reading the net weight, which might be 184.2 grams corresponding to a specific gravity of 1.842.

In this way the two important characteristics of a glaze may be kept very constant and this being accomplished, the remaining problems of spray glazing are much simplified.

Control of Glaze Wastage

Another quite important point is involved in the proportion of the glaze sprayed, to that which actually adheres to the object under treatment. It was found by experiment that under otherwise similar conditions more than twice as much glaze became attached to the object if wetted previous to spraying as was attached when the object was dry.

When a glaze is sprayed into the air a rapid evaporation is set up and much of the glaze reaches the object in too dry a condition to adhere properly. This would indicate the desirability of using the glaze as fluid as other circumstances will allow, or of wetting the surface to be glazed where this is permissible.

By attention to the details discussed, more uniform glazing may be attained and considerable economy in glaze may be effected.

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THE EFFECT OF PARTICLE SIZE OF ZINC OXIDE ON THE CONSISTENCY OF GLAZE SLIPS[1]

By H. G. Thomson

ABSTRACT

No brand of oxide on the market is known to the author which does not have to be calcined to obtain satisfactory results in glazes, and it is further noted that a small amount of PbO present in the various grades is an essential constituent for satisfactory calcination. Microscopic examination showed an increase in particle size after calcining, although differences in uniformity of size and shape existed. The effect of zinc oxide in glaze slips was found to be dependent on its particle size and shape. Therefore the control of consistency of a glaze is simplified by the use of a properly calcined zinc oxide, by which a higher gravity and a more thinning range is obtained.

Introduction

Raw zinc oxide has a suspending action in glaze slips, and it is necessary to use excessive amounts of water in a glaze batch in order to obtain a working consistency for spraying.

Glazes compounded with raw zinc oxide are very apt to dry crack if sprayed soon after milling, and these cracks may develop into parting and crawling of the glazes in the kilns. It is the practice in many glaze laboratories to calcine the zinc oxide to make it possible to obtain a higher gravity for the same working consistency and lessen the chances of dry cracking with its damaging results.

Samples of zinc oxide have been found which fulfilled their purpose as far as color and texture were concerned, but had more or less effect upon consistency. One brand of oxide was found which, when calcined to cone 2 in the regular terra cotta firing, remained nearly as soft and fluffy as the raw oxide. The failure to calcine this brand of oxide properly brought up the question as to what actually took place in the calcining process and what the prerequisites might be for satisfactory calcination.

Effect of Lead Oxide

Chemical analysis of a number of grades of oxide showed the presence of 0.2 to 0.5% of PbO present as $PbSO_4$, in those brands which calcined properly, but an absence of PbO in the sample which proved unsatisfactory. To determine whether so small a quantity of PbO could be responsible for the difference in the results obtained by calcining, 0.5% of litharge was thoroughly mixed with this lead-free brand and calcined to cone 2 in a terra cotta kiln. Considerable shrinkage took place in this test, giving a more dense product which was no longer soft and fluffy, but offered considerable resistance to crushing between the fingers, and had

[1] Presented at the Annual Meeting, American Ceramic Society, Chicago, Ill., February, 1929. (Terra Cotta Division.)

much less suspending action in the glazes. This result obviously indicated that the small amount of PbO present in the various grades is an essential constituent for satisfactory calcination.

A possible explanation of the action of the PbO in the zinc oxide might be derived from the statement of Henry Green.[2]

> When lead sulphate is introduced into the process of making zinc oxide there results what is known as leaded zinc oxide. This material is not a physical mixture of lead sulphate particles and zinc oxide particles but a much more intimate combination. Microchemical analysis has shown that all the particles contain zinc oxide and most, if not all, contain lead sulphate, from which it is evident that a solid solution exists. Apparently any amount of lead sulphate can be dissolved in the zinc oxide.

The various brands of oxide tested in this investigation were not of the leaded type but it would be reasonable to expect that the small amount of $PbSO_4$ present is uniformly distributed and in combination with the zinc-oxide particles which might accelerate their growth at high temperatures.

Examination with the petrographic microscope showed a wide difference in the particle size of the various raw oxides, certain grades being extremely fine and others relatively coarse in comparison. The particle size was found to have increased tremendously after calcining but the magnitude of increase was not the same for all brands. The particles in the lead-free oxide increased slightly but the addition of the 0.5% PbO produced a very marked increase in their size.

Effect of Particle Size of Zinc Oxide

It was noted that a great difference existed in the uniformity of the size and shape of the particles after calcining. Certain brands were composed of quite uniformly sized particles which possessed geometrical similarity in shape while others were made up of particles of different sizes and shapes. The particles of certain oxides were entirely dispersed in the liquid medium used for preparing the slides while others had more of a tendency to form in clusters or aggregates. The particles were found to increase still further in size when calcined to higher temperatures and at cone 10 they were found to be much larger and more uniform than at cone 2.

The effect of the zinc oxide in the glaze slips was found to be dependent upon the particle size, though the actual size of the particle may not be a criterion, for in the case of the formation of aggregates the shape of the particle is probably an important factor.[2] Green found that the oil absorption of the oxide was very greatly influenced by the shape of the particle.

[2] *Paint, Oil, and Chemical Rev.*, April 14, 1927.

Naturally the magnitude of the suspending effect in the glazes depends upon the amount of the oxide used and the batch composition of the glaze. The following glaze has been used to test the various grades of oxide:

	(%)
Frit	35.5
Ball clay	13.0
Zinc oxide	7.0
Feldspar	28.8
Whiting	8.4
Tin oxide	7.3

The composition, water content, and time of milling were constants in all tests and the consistencies of the resulting slips were found to vary between wide limits depending upon the grade of oxide used and its heat treatment.

The extreme limits for the effect of the oxide upon the consistency of this glaze were found with a certain grade which was incorporated in the raw form, calcined to cone 2 and to cone 10. This oxide is extremely fine in the raw form, contains approximately 0.3% PbO and calcines quite satisfactorily at cone 2. When calcined to cone 10, particles of very uniform size and shape which have a minimum effect upon the consistency are obtained. The slips were gaged with a Baumé hydrometer as soon as taken from the mill giving readings of 80, 67, and 56°, respectively. The two glazes containing the calcined oxide could be sprayed as soon as taken from the mill without fear of dry cracking.

Such glazes will become thinner on standing for a few days, and the extent of the thinning is found to be in inverse ratio to the particle size of the zinc oxide, but the glaze containing the raw zinc oxide will not thin to the same consistency as those containing calcined oxide. The 80° glaze would probably thin to 68 to 70°, the 67° glaze to 58 to 60°, and the 56° glaze to 54°.

The effect of the zinc oxide is more noticeable in a glaze containing tin oxide than in one in which Opax has been used as an opacifier. This is probably due to a suspending action of the tin which is lacking in the Opax.

It seems evident that the control of the consistency of a glaze is simplified by the use of a properly calcined zinc oxide, by which a higher gravity and a more narrow thinning range is obtained.

Conclusion

The writer knows of no brand of oxide on the market which does not first have to be calcined in order to obtain satisfactory results in glazes of the type referred to. A grade of oxide having the following characteristics

would be most welcome to those ceramic chemists who depend upon a calcined oxide for a control of the consistency of their glazes.

(1) A degree of purity, such that only the desired effects on texture and color will be produced.
(2) A PbO content not to exceed 0.5% which would not complicate batch calculations, but would be sufficient to accelerate the growth of the particles.
(3) Particles of such size and shape that calcining at the plant would not be necessary to obtain proper consistency in glazes, and as much or little of the oxide could be incorporated in a glaze without fear of dry cracks with their damaging results.

The research departments of two producing companies are said to be working to produce such a product.

Acknowledgment The author wishes to express his appreciation for the interest and helpful suggestions of G. F. A. Stutz and Harvey Brown of the New Jersey Zinc Oxide Company.

MIDLAND TERRA COTTA COMPANY
CICERO, ILLINOIS

THE CAPILLARY SUCTION OF SOME CERAMIC MATERIALS[1]

By A. E. R. Westman[2]

ABSTRACT

The forces which act when clay is mixed with water and when water is removed from wet clay by evaporation have received little study. For this reason, very little definite information regarding the internal mechanism of the drying of clayware is available. In this paper, the writer reviews the experiments and theories of Pukall, Terzaghi, Dixon, etc., lists some of the forces which may act when ware is drying, and defines an important force which he calls "capillary suction." A simple experiment is described, by means of which this force can be readily demonstrated. The development and final form of an apparatus for measuring the capillary suction of ceramic materials is described and data obtained from measurements on a ball clay, a kaolin, flint, feldspar and mixtures of these substances are reported. Capillary suction decreases rapidly with increase in the flint and feldspar of a ceramic body. By utilizing the capillary suction produced by evaporation of water from a clay surface, water at atmospheric pressure has been made to enter a steel bomb in which the gas pressure was maintained at 200 lbs. per square inch.

I. Introduction

(1) Mechanism of Drying The atmospheric conditions which govern the rate of removal of water from the outside surface of a drying mass of clay have been studied extensively in the past and an adequate theory of such drying conditions has been developed. Very little attention, however, has been paid to the forces which act and the movements which take place inside a mass of clay when it is drying and, consequently, it is impossible at the present time to give an adequate picture of the internal mechanism of drying or to present a theory of this mechanism based on sufficient experimental data.

It is well known that large stresses can develop in a clay mass during drying, stresses which are frequently great enough to overcome the tensile strength of the clay and cause cracking. The origin and nature of the force or forces producing these stresses have not as yet been definitely determined.

It is not known definitely whether the water in a drying clay mass is under compression or tension. The forces causing the movement of water from the interior to the exterior of a drying body have not been studied intensively. The effects of aging have not been explained.

(2) Preliminary Experiment The writer's attention was drawn rather forcibly to the presence of an important force, which may act during drying, by means of a simple experiment. The

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[1] The data presented in this paper were obtained in connection with an investigation which was conducted by the Engineering Experiment Station, University of Illinois, M. S. Ketchum, director, under the administration of C. W. Parmelee, Professor of Ceramic Engineering and Head of the Department of Ceramic Engineering. Received May 20, 1929.

[2] Research Associate in Ceramic Engineering, Eng. Expt. Sta., University of Illinois.

apparatus, which is shown in Fig. 1, consisted of a porous pot, a graduated glass tube about 78 cm. long which was admitted to the interior of the pot through a rubber stopper and an Erlenmeyer flask about two-thirds full of mercury which supported a layer of water. The porous pot and glass tube were filled with distilled water and then inverted with the end of the tube dipping in the water of the flask, the admission of air being avoided. The outsides of the porous pot and rubber stopper were then painted with a clay slip and the glass tube allowed to dip into the mercury in the flask. As the slip on the outside of the porous pot dried, water was drawn from the inside of the pot causing the mercury to rise in the tube. When the experiment was first performed it was expected that the mercury might rise as much as 10 cm. Actually it continued to rise until the difference between the mercury level in the tube and that in the flask was 74 cm. Then bubbles appeared in the water above the mercury in the tube and the mercury level remained constant until some time after the inside of the porous pot was filled with vapor, when it dropped back suddenly to the level of the mercury in the flask. The initial rise of the mercury was very rapid but the rate decreased quite noticeably as higher levels were reached.

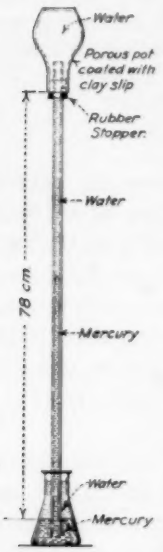

FIG. 1.—Preliminary experiment.

When the mercury level in the tube was 74 cm. higher than that in the flask, evaporation of water from clay film on the porous pot was obviously exerting a suction of about 1 kg. per sq. cm. or 14.2 lbs. per sq. in. and the porous pot was subjected to a pressure equal to this. Much greater suction might have been developed if the water in the pot had not vaporized. It was possible, therefore, that forces of sufficient magnitude to explain shrinkage might be shown by experiments of this kind. The suction caused by the evaporation of water from the surface of the clay was called "capillary suction" as it was probably due to surface tension forces which opposed the retreat of the water surface into the interior of the clay.

(3) Previous Investigations

An examination of the literature showed that the force which we have called "capillary suction" had been recognized by at least two investigators working with clay, W. Pukall[3] and C. Terzaghi.[4] It had been studied by Dixon,[5] Mac-

[3] "Ueber die Vorgange, beim Trocknen keramischer Tonwaren," *Sprechsaal*, **59**, 367–70 (1926).

[4] "Principles of Soil Mechanics," *Eng. News-Rec.*, pp. 742–46, Nov. 5 (1925).

[5] "Transpiration and Ascent of Sap in Trees," *Ann. Rept. Smithsonian Inst.*, **65** [1], 407–25 (1910). Monograph by same title also.

Dougall,[6] Ursprung,[7] and possibly others in connection with the ascent of sap in trees. In a drying mass of clay, capillary suction tends to put the water under tension and the clay particles under compression. Pukall considered that the tension produced in the water was limited by the vapor tension of the water at the temperature of drying. Terzaghi does not mention this possibility but says it is limited only by the size of the pores in the clay and the "intrinsic pressure" of the water, which is about 21,000 atmospheres. Dixon, MacDougall, and Ursprung have shown that water can be put under tension which is much greater than its vapor tension provided the formation of vapor or gas bubbles above a certain size is prevented by having the water wet perfectly all the surface with which it is in contact, or nearly perfectly in a fine-grained material where the bubbles formed will be trapped in small pores and their increase prevented by the action of capillary forces.

Ursprung has shown that even in a simple experiment such as that described in Section 2, it is possible to subject water to tensions greater than its vapor tension, if precautions are taken to secure air-free water and nearly perfect wetting. In one of his experiments, the mercury rose in the tube to a height of over 151 cm. above that in the flask, indicating a negative pressure of over one atmosphere. By indirect calculations based on compression experiments, Terzaghi calculated the maximum capillary suction (transition pressure) of a yellow residual clay to be 2433 lbs. per sq. in. and that of a blue marine clay to be 4823 lbs. per sq. in.

The theories advanced by Lines[8] and Brand,[9] differ from those of Pukall and Terzaghi; Lines, for example, concluded that the water in the center of a mass of clay is under pressure during the drying process.

(4) Theory of Drying While the studies of Pukall, Terzaghi, Dixon, Ursprung, and others have thrown much light on the internal mechanism of drying, there is still much to be done.

Pukall considers that clayware dry on the inside before they do on the outside because the interior water is put under tension and vaporizes. While it appears possible for this to take place under certain conditions,[10] particularly in humidity driers, the adhesion of water to clay must be taken into account, as well as the capillary forces which tend to stop the growth of a bubble in a fine-grained body and the resistance offered to the flow of water from the interior to the surface.

[6] Reversible Variations in Volume, Pressure, and Movements of Sap in Trees, Carnegie Inst. Washington (1925).

[7] *Ber. deut. Botan. Ges.*, **31,** 388 (1913); *ibid.*, **33,** 253 (1915); *ibid.*, **34,** 475–88 (1918); *ibid.*, **36,** 514 and 577 (1918); etc.

[8] "Notes on the Drying of Clay," *Trans. Amer. Ceram. Soc.*, **10,** 146 (1908).

[9] "De-Airing as a Corrective in Drying," *Jour. Amer. Ceram. Soc.*, **4,** 189–96 (1926).

[10] Experiments indicate that this happens with silica gels. See Colloids, a textbook by H. R. Kruyt (translated by H. S. van Klooster).

Practically all experimental determinations of moisture gradients in drying clayware[11] show a greater percentage moisture in the center of a mass than near its surface. On the other hand, the situation is probably not as simple as that described by Terzaghi, since for relatively impermeable bodies, the effect of capillary suction may not be appreciable except in the immediate neighborhood of the outside surface. There is also the possibility, especially in humidity driers, of the formation and growth of bubbles of vapor as pictured by Pukall.

(5) Purpose of Paper From what has been said it is evident that quantitative information regarding the forces which may act in a drying mass of clay is essential for further progress in this field. Some of the forces which might be studied are the forces of "wetting" or the adhesion between clays and water which may tend to prevent the formation of bubbles even at very high tension,[12] the forces which tend to prevent the growth of a bubble of vapor in clays,[13] the capillary suction of clays, and the permeability of clays to water.[14] Accurate determinations of the moisture gradients in clays under a variety of conditions and direct measurements of the pressure in the interior of drying masses of clay[15] would also be very useful in building up an adequate theory of drying.

It is the purpose of this paper to describe an apparatus and a method for the direct determination of the capillary suction of ceramic materials which has been developed and to report some of the measurements which have been made.

(6) Principles If a material is thoroughly saturated with water, bubbles do not form in its interior and water can flow freely to the surface, evaporation from the surface of the material will result in (1) a compression of the material with a corresponding development of tension in the pore water and (2) a retreat of the water-to-air contact surface from the outside of the material toward the interior. We may define the capillary suction of the material as the maximum difference which can exist between the pressure of the pore water and the pressure of the air in contact with the material without causing the water-to-air contact surface to retreat to the interior.

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[11] D. C. Lindsay and W. H. Wadleigh, "Observations on the Drying Properties of Clays," *Jour. Amer. Ceram. Soc.*, **8** [11], 677–93 (1925); Troop and Wheeler, "Drying of Clay under Definite Conditions," *Trans. Ceram. Soc.* [Eng.], **26,** 3 (1926–27).

[12] Dixon (see footnote 5) has shown that sap wets tree fibers nearly perfectly.

[13] Bartell, Fifth National Colloid Symposium, has measured similar forces for organic liquids and carbon black.

[14] Terzaghi (see footnote 4) has measured the permeability of clay soils. Schurecht (*Jour. Amer. Ceram. Soc.*, **5,** 930 (1922)) has determined the mechanical movement of water through certain clays.

[15] MacDougall (see footnote 6) has made direct measurements of the tension in the sap of the tree.

The determination of this maximum pressure difference by experiments in which the air is at atmospheric pressure and the pore water is under tension, as in the experiment described in Section 2, presents many difficulties. In the apparatus to be described, these difficulties were avoided by using air at pressures greater than atmospheric and keeping the pore water at atmospheric pressure.

The principle of the apparatus is shown by the diagram in Fig. 2. The lower surface of the specimen, which consists of a thin disk of the material under test thoroughly saturated with water, is kept in contact with water at practically atmospheric pressure by means of a saturated water-permeable support, which is in direct contact with water. The upper surface of the specimen is in contact with nitrogen,[16] the pressure of which may be raised by the admission of nitrogen from a cylinder of compressed nitrogen and may be measured by a pressure gage. A seal prevents the escape of nitrogen around the edges of the specimen.

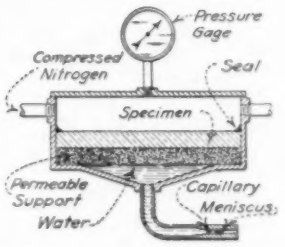

FIG. 2.—Principle of apparatus.

The nitrogen pressure is increased gradually until the point is reached at which the nitrogen enters the pores of the specimen and escapes, driving the water before it. If cracking of the specimen has been avoided, this pressure will be equal to the capillary suction of the material under test.

Since it is conceivable that high nitrogen pressures might be reached merely because the material under test closed the pores in the permeable support, arrangements were made for passing nitrogen over the surface of the specimen and for detecting any movement of water through the specimen by observation of movements of the meniscus in the capillary tube shown in Fig. 2. If the evaporation of water from the upper surface of the specimen caused a movement of the meniscus in the capillary which was too large to be explained by cooling effects, it was evident that the ability of the specimen to withstand nitrogen pressure was not due to closing of the surface pores of the permeable support.

(7) Description of Apparatus After some preliminary experiments with air at pressures of 70 lbs. per sq. in. and lower, the apparatus shown in Fig. 3 was developed. It consisted of a steel bomb, two needle valves, two pressure gages and a cylinder of compressed nitrogen. These were connected by high-pressure pipe connections so that nitrogen from the cylinder could be admitted slowly to the bomb by means of one needle valve. A 2000 lb. per sq. in. pressure

[16] Nitrogen was used instead of air as it could be obtained readily in a highly compressed condition.

gage was connected directly to the bomb, a 100 lb. per sq. in. pressure gage could be used for measuring low pressures by closing a stop-cock at the outlet. A steel nipple screwed into the bottom of the bomb was connected to a horizontal capillary tube by rubber tubing. The needle valves, bomb, and pipe fittings, with the exception of those to the left of the second needle valve, were designed for working pressures of 3500 lbs. per sq. in. with a safety factor of 8 or greater.

The construction of the bomb and of the perforated steel plate, which formed part of the permeable support for the specimens, are shown in Fig. 4. In the first experiments, a disk of bronze gauze was placed below the permeable support so water entering the bottom of the bomb would have access to all perforations of the plate. At high pressures, however, the gauze contracted sufficiently to cause undesirable movements of the plate and was discarded, the plate being grooved so that all the perforations were

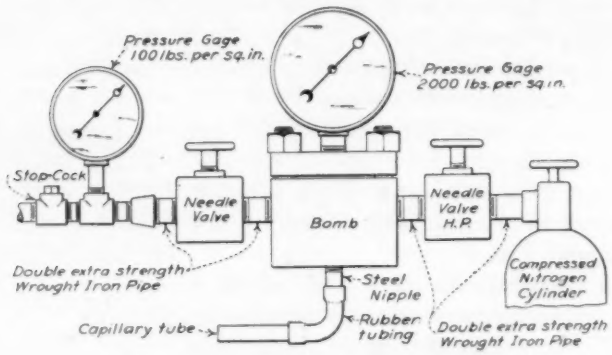

FIG. 3.—Capillary suction apparatus.

interconnected. The bomb was designed so as to have a small inside volume and to bring as much of the nitrogen as possible in contact with the specimen.

The permeable support for the specimen consisted of the perforated steel disk shown in Fig. 2, a disk of bronze gauze (60-mesh) about $^1/_4$ in. smaller in diameter and a hard filter paper (Whatman No. 50). The perforated steel disk supported the gauze, which in turn supported the filter paper which was in direct contact with the specimen. At first the gauze was merely pressed against the perforated plate but after a great deal of trouble with cracking of specimens was traced to the springing of the gauze, it was wired as rigidly as possible to the perforated plate.

(8) Operation The permeable support consisting of the perforated steel plate, wire gauze, and filter paper was placed in the bomb; water was forced in through the capillary tube and nipple shown in Fig. 3 until it covered the filter paper and then the specimen was introduced and sealed in place, care being taken to avoid trapping of air. With

the outlet stop-cock closed and the left needle valve open (see Fig. 3), nitrogen was admitted so as to raise the pressure at a rate of about 4 lbs. per sq. in. per minute, the pressure being read on the 100-lb. gage. When a pressure of 100 lbs. per sq. in. was reached the left needle valve was closed, the stop-cock opened and the elevation of the pressure continued at a rate of about 40 lbs. per sq. in. in one minute, the pressure being shown by the 2000-lb. gage. The pressure at which water was expelled through the capillary and the nitrogen escaped was then found and recorded.

Occasionally, a second specimen was held at a pressure about 20 lbs. per sq. in. below the maximum pressure found for the first specimen, the needle valves were adjusted so that nitrogen passed over the specimen and escaped from the outlet at a rate of about 50 cc. per minute and the meniscus in the capillary tube was watched. In all the experiments of this type which were performed, the meniscus was found to move along the capillary tube and into the rubber tube in about one-half hour, showing that the pores of the permeable support were not clogged.

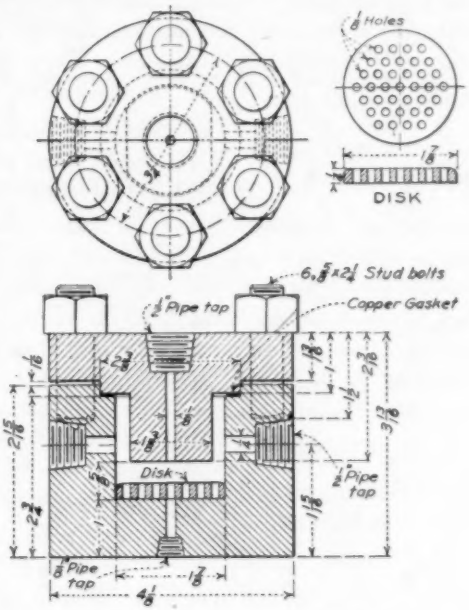

FIG. 4.—Steel bombs; working pressure, 3500 lbs./sq. in.

(9) Calibration The pressure gages which were used in the experiments were calibrated to 200 lbs. per sq. in. by an apparatus of the usual type in which known pressures are developed in oil contained in a cylinder which was equipped with a rotating piston loaded with standard weights. The 2000-lb. gage was calibrated by a similar apparatus in which loading was accomplished by a moving weight and beam.

II. Measurements

(10) Materials Measurements of the capillary suction of the following materials were made: Ottawa flint, Buckingham feldspar, South Carolina (McNamee) kaolin, Whiteway English ball clay, and mixtures of these substances in which the ratio of kaolin to ball clay

was fixed and the percentage of the nonclay ingredients was varied. The different substances and mixtures are listed in Table I.

TABLE I

Composition of specimens				Capillary suction		
Flint	Feldspar	Ball clay	Kaolin	No. of tests	Average (lbs./sq. in.)	Probable error (lbs./sq. in.)
100					5	
	100			3	10	
		100		3	880*	
			100	3	263	±5.5
		40	60	3	400	±6.4
50		20	30	6	182	±6.1
	50	20	30	6	198	±5.4
20	30	20	30	4	192	±5.8
10	15	30	45	6	263	±6.4
30	45	10	15	5	33.9	±2.0

* This may not be the maximum pressure. The values obtained were 800, 760 and 880 lbs./sq. in.

(11) Preparation of Specimens In the case of flint and feldspar, the powders were mixed with water to form a stiff paste, were molded and transferred to the bomb in a rather soft condition. A small nitrogen pressure was applied in order to consolidate them and then a seal of Whiteway English ball clay was used.

For the clays and mixtures containing clays 3 kg. batches were made up, blunged, allowed to dry to the plastic condition in cloth-covered plaster bats, wedged very carefully, and allowed to stand in damp jars. Thin disks of the plastic material were molded in a plaster mold and then transferred to the bomb where they were pressed into place and sealed by one of the methods described in the following section.

(12) Sealing and Avoiding Cracks The escape of nitrogen from the bomb by way of the nipple and capillary tube at the bottom could be brought about by (1) cracking of the specimen, (2) failure of the seal, and (3) neutralization of the capillary suction by the pressure of the nitrogen. The greatest difficulty was encountered in preventing the occurrence of the first two phenomena and about 80 runs were made before a technique was developed which gave assurance that the third had occurred. The precautions necessary to avoid cracking of the specimen were found to be (1) thorough wedging, (2) tamping the specimen in place by means of a cloth-covered wooden piston which fitted loosely in the bomb, and (3) rigid support for the specimen.

Three methods of sealing were found to give satisfactory results under suitable conditions. In work with materials having small capillary suctions, a seal of Whiteway English ball clay was found to be effective. Its effectiveness was increased considerably if the pressure were released and the bomb opened after each 50 or 100 lbs. per sq. in. increase in pressure and the seal tamped. Pressures of 700 lbs. per sq. in. could occasionally be reached by this method without seal failure.

In the second method of sealing, the steel ring shown in Fig. 5 was placed on top of the specimen and pressed against it. The steel ring itself was then sealed to the bomb with ball clay. The use of the ring increased the length of the possible path of escape of nitrogen around the sides of the specimen.

The steel ring was also used in the third method of sealing in which mercury was used as a seal between the ring and the inside walls of the bomb. The last two methods were particularly applicable to specimens which were subject to shrinkage, because the ring would, to some extent, move down as the specimen contracted.

When no cracks in the specimen were visible under a magnifying glass after an experiment, if failure of the seal could not be detected, if repeated experiments with different seals gave consistent values, and if certain characteristic changes in the appearance of the specimen took place, it was considered that failure of the seal and cracking of the specimen had not occurred.

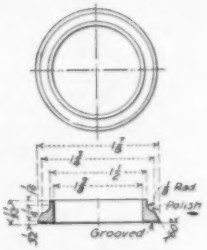

FIG. 5.—Steel seal ring.

With specimens composed wholly of ball clay a completely satisfactory solution of the difficulties described in the foregoing was not obtained. The very pronounced shrinkage which occurred and a small though persistent lateral contraction of the specimen at high pressures were the main sources of difficulty. At about 600 lbs. per sq. in. pressure the specimens were compressed to a practically leather-hard condition and it is possible that in future work, seals formed of such materials as beeswax applied after the specimen has been subjected to 600 lbs. per sq. in. pressure may prove successful. Sufficiently high pressures were obtained, however, to show that the capillary suction of ball clay greatly exceeded that of the other materials tested. For the other materials, maximum pressures were no doubt reached.

(13) Data Obtained The average capillary suctions of the materials investigated are reported in Table I, where the composition of the specimens, the number of the determinations, the average maximum pressure obtained and its probable error estimated from the Small Sample Theory are reported.

With the exception of the ball clay, only the values obtained in the final experiments in which cracking of the specimen and failure of the seal were known not to have occurred are included. For the ball clay, the value given may not be the maximum pressure obtainable as the method of sealing was not dependable.

(14) Observation Some phenomena observed in the course of the experiments may be of interest. It was found, for example, that the application of nitrogen or air pressure to a specimen

supported in the bomb caused the specimen to contract and decrease in water content. When the pressure was first applied, water exuded from the capillary tube (see Fig. 3) rather freely until equilibrium was obtained. When the pressure was raised, more water was exuded but at high pressures a very large increase in pressure was necessary to force out a relatively small amount of water.

Ball clay, treated in this way, became leather-hard and had a waxy sheen when cut with a knife. Kaolin specimens were consolidated, became very short, and broke, when flexed, along lines quite different from the fracture lines of an uncompressed specimen.

Experiments in which drying of the top of the specimen resulted in a movement of water into the bomb were performed with pressures as high as 200 lbs. per sq. in. and could very probably be made at higher pressures. Such experiments provide a rather striking demonstration of capillary suction, the movement of water at atmospheric pressure into a bomb in which the pressure is 200 lbs. per sq. in. being a phenomenon which ordinarily would be considered impossible.

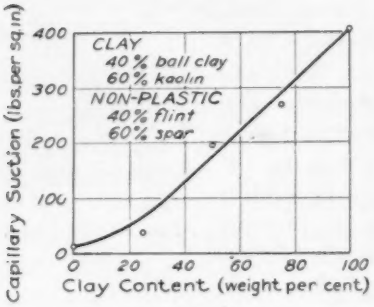

FIG. 6.

(15) Capillary Suction and Clay Content The relation between the capillary suction of the mixtures tested and their clay content is shown in Fig. 6, which was constructed by means of the data given in Table I. It will be seen that the addition of nonplastic materials to a mixture of ball clay and kaolin caused a marked decrease in capillary suction.

III. Summary

(16) Theory of Drying The need of intensive experimental study of the capillary forces acting when clayware is drying to serve as a basis for an adequate description of the internal mechanism of drying has been pointed out. The studies of Pukall, Terzaghi, Dixon, MacDougall, Ursprung and others have been briefly reviewed and their connection with the drying theory pointed out.

(17) Capillary Suction Of several forces which presumably influence the drying conduct of a ceramic body, capillary suction was chosen for study. It has been defined and its possible connection with the progress of drying pointed out. A method and apparatus for its determination have been described.

(18) Data The capillary suctions of flint, feldspar, a ball clay, a kaolin, and mixtures of these substances have been determined, the values obtained for the ball clay being possibly too low. The effect of the introduction of flint and feldspar into a clay body on its capillary suction has been determined.

IV. Conclusions

The clays tested had a much higher capillary suction than the nonplastic materials, the ball clay had a capillary suction at least three times as great as that of the kaolin, and the introduction of flint and feldspar into a body formed of kaolin and ball clay lowered its capillary suction very markedly. By utilizing capillary suction, water under atmospheric pressure can be made to enter a bomb in which the gas pressure is as high as 200 lbs. per sq. in. and presumably higher. A great deal of study in this field remains to be done, the work described in this paper being published at this time because it constitutes a small step in what the writer considers a fruitful direction for further study.

Acknowledgments The writer is indebted to Prof. C. W. Parmelee, Head of the Department of Ceramic Engineering, for his interest and help and to I. W. Shoeninger and B. R. Windsor, students in the Department, for their assistance with the experimental work.

EFFECT OF WATER IN EXPANDING CERAMIC BODIES OF DIFFERENT COMPOSITIONS[1]

By H. G. Schurecht and G. R. Pole[2]

ABSTRACT

The effects of the composition of some ceramic bodies on their moisture expansions were investigated. With the exception of mixtures containing blast-furnace slag or magnesite, most bodies with high absorptions developed considerable expansion. Bodies with low absorptions composed of pure clay and feldspar developed practically no moisture expansion while those composed of clay, feldspar, and more than 20% silica developed considerable moisture expansion. By adding magnesite, the resistance of a ceramic body to moisture expansion was improved. Additions of whiting, iron oxide, and titanium oxide were not as beneficial as magnesite. It was found that crazing caused by moisture expansion of bodies can usually be prevented by proper manufacturing control.

I. Introduction

It has been shown[3] that a type of delayed crazing found on glazed ceramic ware may in certain cases be caused by a gradual expansion of the body during storage or use produced by the action of moisture while the glaze generally does not expand in the same manner. This type of expansion may be called "moisture expansion" to distinguish it from other types. It has furthermore been shown that expansions of ceramic bodies similar in magnitude to those obtained during long periods of storage may be produced by subjecting them to steam at a pressure of 150 pounds per square inch for one hour in an autoclave. This treatment was, therefore, suggested as an accelerated test for indicating whether crazing from this expansion will develop in time on ceramic bodies.

In general, this type of crazing is less apt to occur on vitreous than on porous bodies although it may develop on some vitreous bodies. This led to the belief that it may depend upon the composition of the body as well as the degree of vitrification. Studies were made, therefore, to determine the effects of additions of different substances to ceramic bodies upon their expansions when treated with water or steam.

It was found that the expansion of the body depends upon the mineral and chemical composition of the body as well as its absorption and therefore can be reduced and often prevented by proper manufacturing control. The results of the investigations warranting this conclusion are given.

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[1] Publication approved by the Director of the Bureau of Standards of the Department of Commerce, and the National Terra Cotta Society. Received May 2, 1929.

[2] Research Associates of the National Terra Cotta Society at the National Bureau of Standards.

[3] "Methods for Testing Crazing of Glazes Caused by Increases in Size of Ceramic Bodies," *Jour. Amer. Ceram. Soc.*, **11**, 271–77 (1928).

II. Experimental Methods

To determine the moisture expansions of the bodies, bars 24 inches long were fired to cone 6. This firing would drive off any combined water which might be present. Shortly after firing and cooling to 20°C, their lengths were measured by means of a microscopic comparator.[4] They were then completely immersed in water for 168 hours after which their lengths were measured while wet and also after drying at 110°C for 12 hours. The same specimens were then kept immersed under water for 240-hour and 312-hour periods and their wet lengths were measured after each soaking period. They were dried at 110°C for 20 hours and their dry lengths at 20°C were measured. The specimens were then boiled in water 4 hours after which their wet and dry lengths were again measured. Their lengths were also determined at 20°C subsequent to subjecting them to steam at pressures of 75, 100, and 125 pounds per square inch for one hour. All absorption tests were made by 5 hours boiling in water.

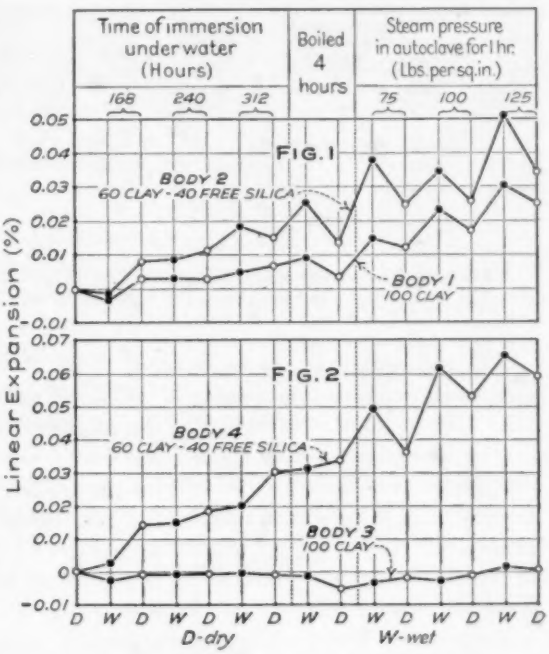

FIG. 1.—Effect of crystalline silica on changes in size of an open-firing pure clay due to water treatments.

FIG. 2.—Effect of crystalline silica on changes in size of a tight-firing pure clay due to water treatments.

III. Effects of Silica

The mixtures given in Table I were used to study the effects of silica on the moisture expansions of several types of ceramic bodies. The average percentages of moisture expansion, measured and computed as the

[4] The comparator used in this work was designed by C. S. Laubly of the Bureau and is described in "Shrinkage of Portland Cement" by J. C. Pearson, Amer. Concrete Inst., 1921.

per cent linear expansion, in terms of the original dry lengths of the open firing bodies with and without free silica added are shown in Fig. 1. These values represent the averages obtained on two specimens in each case.

TABLE I

COMPOSITION OF CERAMIC BODIES CONTAINING VARYING AMOUNTS OF CLAY AND FREE SILICA

Body No.*	Bonding portion of body				Composition of cone 6 grog			Clay and free silica in terms of total weight (%)		Absorption after five hrs. boiling (%)
	English ball clay	Florida kaolin	Potter's flint (quartzite)	Diatomaceous silica	English ball clay	Florida kaolin	Potter's flint (quartzite)	Clay	Free silica	
1	19.5	45.5			10.5	24.5		100		14.8
2	9.75	29.25	26.0		5.25	15.75	14.0	60	40	19.6
3	65.0				35.0			100		0.7
4	39.0		26.0		21.0		14.0	60	40	10.3
5	5.0		95.0					5	95	16.8
6	20.0		80.0					20	80	15.2
7	17.5			82.5				17.5	82.5	

* The first four bodies will be designated as follows in this Report: (1) open-firing clay; (2) open-firing siliceous clay; (3) tight-firing clay; and (4) tight-firing siliceous clay.

It is apparent that the open-firing "pure clay"[5] body which expanded considerably due to the action of water, expanded decidedly more after the addition of 40% silica. Drying the specimens which have been immersed under water often increased their lengths. Heating the wet specimens during drying probably causes the water to react with the body. After the specimens have been boiled or treated in an autoclave, however, they contract instead of expand upon drying. Why this obtains remains to be explained.

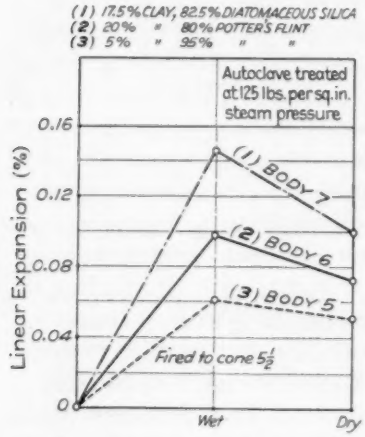

FIG. 3.—Expansions of diatomaceous silica and potter's flint when mixed with small percentages of clay.

From Fig. 2 it can be seen that the addition of silica increased the moisture expansion of tight-firing pure clay bodies to a greater extent than it did open-firing pure clay bodies. For example, the tight-firing pure clay body developed practically no expansion when treated in the autoclave but with 40% silica it expanded about 0.065%.

It appears, therefore, that the tendency of ceramic bodies to develop moisture expansion may be decreased by selecting clays low in quartzite,

[5] By "pure clay" is meant high grade commercial clays, such as ball clays and kaolins containing less than 5% free silica.

which is generally the most common form of free silica in clays. It is evident from the results shown in Fig. 3 that amorphous silica, such as diatomaceous silica, may increase the moisture expansion to a greater extent than quartzite but this form of silica is seldom found in large amounts in clays such as are used for making fired clay products. This may be due to the fact that diatomaceous silica is more colloidal in nature than quartzite.

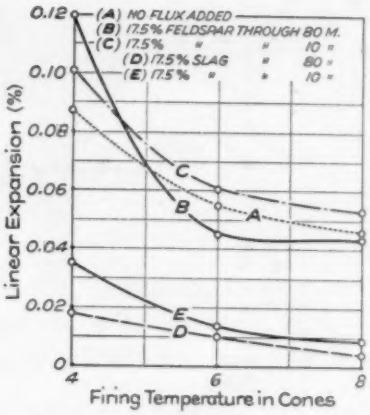

FIG. 4.—Effects of feldspar and slag additions to a clay body on its expansion due to autoclave treatment after firing to different temperatures.

IV. Effects of Blast-Furnace Slag and Feldspar

The effects of blast-furnace slag and feldspar additions on the moisture expansions of some bodies containing grog were determined after firing to different temperatures the bodies whose compositions are given in Table II. The results are given in the table and plotted in Figs. 4 and 5.

It was found that the addition of a blast-furnace slag to the body decreased its moisture expansion to a marked degree. The addition of feldspar in a few cases reduced this expansion only slightly whereas in most cases it was increased. As a rule the bodies containing 80-mesh as compared to 10-mesh feldspar showed lower expansion. More intimate mixtures can be obtained with finely-ground material. The reverse is true with low-fired bodies, the reason for which remains to be determined.

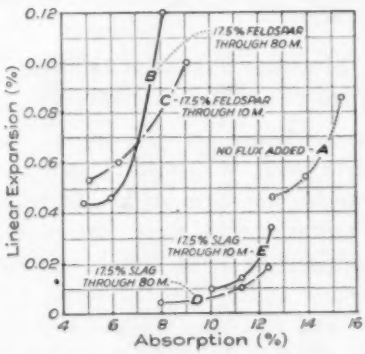

FIG. 5.—Relation between absorptions and expansions of some bodies due to autoclave treatment.

Increasing the firing temperature of all bodies from cone 4 to cones 6 and 8 and thereby reducing their absorptions also reduced the moisture expansions. There is, however, apparently no direct relation (see Fig. 5) between absorptions and moisture expansions of bodies of different compositions. Bodies containing feldspar, *e.g.*, have comparatively low absorptions but develop relatively high moisture expansions whereas bodies with blast-furnace slag may have much higher absorptions but still develop lower moisture expansions. For

bodies having the same compositions, however, the moisture expansion increases with an increase in absorption.

TABLE II

MOISTURE EXPANSIONS AND ABSORPTIONS OF BODIES CONTAINING BLAST-FURNACE SLAG AND FELDSPAR AFTER BEING FIRED TO DIFFERENT TEMPERATURES

		Fired to cone 4			Fired to cone 6			Fired to cone 8		
		Expansion after treatment in autoclave at 150 lbs. per sq. in. for 1 hr. (%)		Absorption after 5 hrs. boiling (%)	Expansion after treatment in autoclave at 150 lbs. per sq. in. for 1 hr. (%)		Absorption after 5 hrs. boiling (%)	Expansion after treatment in autoclave at 150 lbs. per sq. in. for 1 hr. (%)		Absorption after 5 hrs. boiling (%)
No.	Composition (%)	Wet	Dry		Wet	Dry		Wet	Dry	
A	65 clay[1] 35 grog	0.0895	0.0737	15.4	0.0574	0.0527	14.0	0.0464	0.0443	12.6
B	60 clay 22.5 grog 17.5 slag through 80-mesh	0.0182	0.0149	12.4	0.0099	0.0107	11.3	0.0052	0.0035	8.1
C	65 clay 17.5 grog 17.5 slag through 10-mesh	0.0339	0.0283	12.6	0.0124	0.0103	11.3	0.0070	0.0069	10.1
D	60 clay 22.5 grog 17.5 feldspar through 80-mesh	0.1204	0.0994	8.2	0.0464	0.0425	5.9	0.0430	0.0381	5.0
E	65 clay 17.5 grog 17.5 feldspar through 10-mesh	0.1119	0.0899	9.2	0.0594	0.0528	6.4	0.0540	0.0513	5.1

[1] The clay used in these bodies was a No. 2 fire clay and the grog employed was calcined fire clay ground to pass through a 10-mesh sieve.

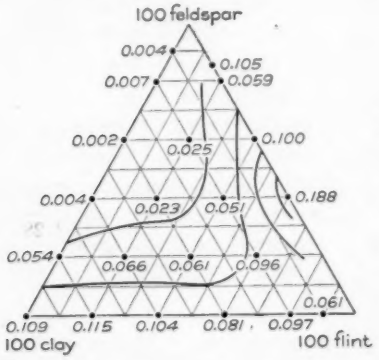

FIG. 6.—Expansions of clay-feldspar-silica mixtures due to autoclave treatments. (Specimens were fired to cone $5^1/_2$.)

V. Moisture Expansions of Clay, Feldspar, and Flux Mixtures

The moisture expansions of the mixtures given in Table III containing varying amounts of clay, feldspar, and potter's flint were determined after immersing the specimens in water 40 hours and boiling in water two hours, and also after treating them in an autoclave at 150 pounds per square inch steam pressure for one hour. The results are given in Table III and are plotted in Figs. 6 and 7.

It is evident from the results plotted in Fig. 6 that the addition of feldspar

to "pure clay" materially reduces the moisture expansion of the fired body, whereas the addition of feldspar to siliceous clay reduces the moisture expansion only slightly. They also indicate that a mixture of feldspar and silica may develop a greater moisture expansion than either feldspar or flint alone. This expansion was found to be greatest with a mixture composed approximately of 40% feldspar and 60% flint, indicating a reaction between the flint and silica.

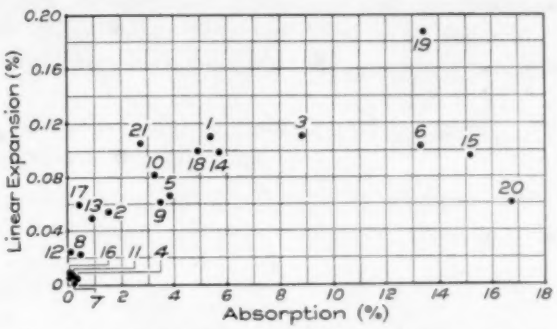

FIG. 7.—Relations between the absorptions of clay-feldspar-silica mixtures and their expansions due to autoclave treatments. (Body numbers are indicated for each point.)

The relations between absorptions and moisture expansions of the mixtures are shown in Fig. 7. The moisture expansions of all mixtures with high absorptions are usually large. Of the mixtures with low absorptions, those composed of "pure clay" and feldspar have developed

TABLE III

MOISTURE EXPANSIONS OF CLAY, FELDSPAR, AND FLINT MIXTURES AFTER HAVING BEEN FIRED TO CONE $5^1/_2$

Body No.	Composition			Expansion (%)			Absorption after 5 hrs. boiling (%)
	Tenn. No. 5 ball clay	Maine feldspar	Potter's flint (quartzite)	Soaked in water 40 hrs., boiled 2 hrs. and dried at 110°C	Treated in an autoclave at 150 lbs. per sq. in. steam pressure for 1 hr.		
					Wet	Dry	
1	100			0.032	0.109	0.063	5.44
2	80	20		0.040	0.054	0.067	1.51
3	80		20	0.014	0.115	0.078	8.86
4	60	40		−0.002	0.004	0.000	0.38
5	60	20	20	0.016	0.066	0.062	3.87
6	60		40	0.008	0.104	0.066	13.45
7	40	60		−0.004	0.002	−0.008	0.29
8	40	40	20	0.011	0.023	0.010	0.46
9	40	20	40	0.002	0.061	0.051	3.52
10	40		60	0.011	0.081		3.28
11	20	80		0.004	0.007	0.005	0.18
12	20	60	20	0.010	0.025	0.021	0.20
13	20	40	40	0.015	0.051	0.043	0.97
14	20	20	60	0.016	0.096	0.088	5.68
15	20		80	0.035	0.097	0.073	15.22
16	5	95		−0.009	0.004	0.000	0.15
17		80	20	0.011	0.059	0.058	0.41
18		60	40	0.011	0.100	0.079	4.98
19		40	60	0.040	0.188	0.162	13.44
20	5		95	0.016	0.061	0.051	16.80
21		85	15	0.010	0.105	0.090	2.70

practically no expansion, whereas those composed of clay, silica, and feldspar have developed considerable moisture expansion. Note the difference between clay, silica, and feldspar mixtures, clay and silica, and clay and feldspar, two component mixtures (see Fig. 6).

It must be remembered that these bodies were fired to cone $5^1/_2$; different results would be obtained if they are fired to different temperatures.

VI. Effects of Iron Oxide, Calcium Carbonate, Magnesium Carbonate, and Titanium Oxide

The mixtures given in Table IV were studied to determine the effects of iron oxide, calcium carbonate, magnesium carbonate, and titanium

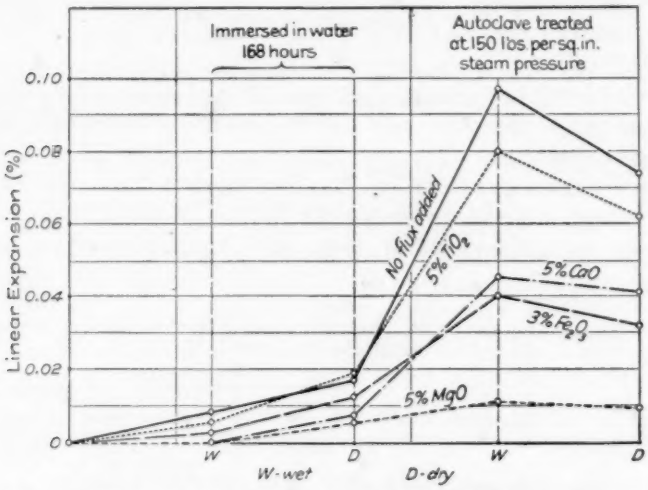

FIG. 8.—Effects of TiO_2, CaO, Fe_2O_3, and MgO additions on the tendency of clay bodies to expand from water treatments.

oxide upon the moisture expansions of ceramic bodies. Sufficient magnesium and calcium carbonates were added, as magnesium and whiting, respectively, to the bodies to introduce the equivalents of 5%, respectively, of magnesium and calcium oxides.

It is apparent from the results shown in Table IV and Fig. 8 that finely-ground magnesite was most effective for reducing the moisture expansion of this body since the addition of 10.5% reduced the expansion from 0.097 to 0.011%.

Three per cent iron oxide reduced the expansion caused by autoclave treatment to 0.040%, which is not so effective as the addition of 10.5% magnesite to the body. Adding 8.95% whiting to the body reduced the moisture expansion caused by autoclave treatment to 0.045%. It is

also not as effective as magnesite. Adding 5.0% titanium oxide to the body decreased the expansion to 0.079%, being less effective than the other fluxes used.

TABLE IV

EXPANSIONS CAUSED BY WATER TREATMENTS OF BODIES CONTAINING WHITING, MAGNESITE, IRON OXIDE AND TITANIUM OXIDE

(Specimens were fired to cone 7)

No.	Additions to a body composed of 75% Tennessee No. 9 ball clay and 25% grog	Expansion caused by immersing in water 168 hours (%)		Per cent expansion caused by treatment in an autoclave at 150 lbs. per sq. in. pressure for 1 hr.		Absorption after 5 hrs. boiling
		Wet	Dry	Wet	Dry	
1	Body with no additions	0.008	0.017	0.097	0.073	10.1
2	8.95% calcium carbonate through a 200-mesh sieve	0.001	0.007	0.045	0.042	11.8
3	10.5% magnesium carbonate through a 200-mesh sieve	0.001	0.006	0.011	0.009	8.9
4	3% iron oxide	0.002	0.012	0.040	0.032	7.5
5	5% titanium oxide	0.006	0.018	0.079	0.062	9.1

The relation between absorptions and moisture expansions of these mixtures is shown in Fig. 9. It is evident that the body containing 5% magnesium oxide has a low moisture expansion in spite of the fact that it has a comparatively high absorption, whereas bodies containing the other fluxes have developed relatively high moisture expansions.

It seems evident from these results that by using finely ground magnesite or dolomite as a flux in place of whiting in ceramic bodies, their resistance to moisture expansion can be improved.

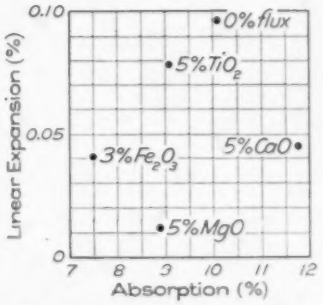

FIG. 9.—Relation between absorptions and expansions of bodies containing CaO, MgO, Fe_2O_3, and TiO_2.

VII. Summary and Conclusions

(1) Fired mixtures of "pure clay" and feldspar, with low absorptions, showed comparatively low moisture expansions when subjected to steam at 150 pounds per square inch pressure for one hour. Similar mixtures with low absorptions but containing 20% free silica, however, expanded considerably.

(2) With the exception of bodies containing slag or magnesite, all others tested having high absorptions developed considerable moisture expansions.

(3) The moisture expansion of a siliceous fireclay body was decreased by the addition of blast-furnace slag, while the expansion was increased in some cases and reduced only slightly in others by the addition of feldspar.

(4) By adding finely-ground magnesite to a ball clay body, the moisture expansion was reduced more than by the addition of whiting, iron oxide,

or titanium oxide. The magnesite used was ground to pass a 200-mesh sieve in this case. Coarsely-ground magnesite may not be as beneficial as this finely-ground material.

(5) Increasing the firing temperature of ceramic bodies reduces their moisture expansion to a marked extent in most cases.

CERAMIC ABSTRACTS

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ROSS C. PURDY, Editor

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Abrasives

Grinding tungsten-carbide tools. ANON. *Abrasive Ind.*, **10** [7], 22 (1929).—Although tungsten-carbide is exceptionally hard, as smooth an edge can be produced on it as on high-speed steel and in the same grinding time, although special grinding tools are necessary. The material should be ground wet with a copious supply of water. The roughing operation should be followed by finish grinding on a finer wheel than that used for roughing. The peripheral speed of the wheel should be 65 to 85 ft. per sec., or from 3900 to 5100 surface ft. per min. The pressure should not be greater than that required for ordinary high-speed steel, and excessive pressure must be avoided. If the material is ground dry, high heating must be avoided, as well as sudden shock by dipping the tool in water. In wet grinding, local heating should be avoided. Sudden changes of temperature are liable to cause cracks spoiling the tool. Well-balanced, true grinding wheels on smoothly running shafts are also necessary to obtain sharp edges. In order to economize in the grinding, only the tungsten-carbide tip is ground on the special wheel. Final finish grinding should be done by hand and not by machine grinding. E.P.R.

Lapping gears and worms. H. J. WILLS. *Abrasive Ind.*, **10** [7], 25 (1929).—

The lapping of gears is important wherever quiet and smooth running parts are essential. Soft and hardened gears of the spur, helical, bevel, internal, and herring-bone types all require lapping to remove cutter marks, imperfections in tooth profile, spacing, and to correct for distortions caused from heat treating. After the gear has been mounted and is in motion, the lapping compound should be applied with a paint brush in sufficient quantity to wet the entire surface of the gear teeth and in the case of large gears, the surface should be moistened with kerosene or machine oil before applying the compound. The best results are obtained if the gears are lapped under light load and at such speeds as will not cause the compound to fly. In small plants where production is more or less intermittent, the gears and worms can be assembled and satisfactorily lapped in their housings. If this method is employed, the compound should be applied sparingly so that it will not flow or drip into the bearings or housings. Successful lapping of gears and worms calls for the use of special lapping compounds which are supplied for this purpose. E.P.R.

Disk grinders finish work with large areas. ANON. *Abrasive Ind.*, **10** [7], 21–22 (1929).—In grinding solid areas as large as those which some draft gear plates present, particularly when the metal is tough as it is in this case, the exertion of much manual effort is required when the ordinary hand-operated disk grinder is used. The mechanically oscillating work tables with which the grinder is equipped were designed to eliminate such manual effort, reducing labor turn-over and stimulating production. Both work tables rock or oscillate automatically, and are fed toward the grinding member by spring tension. The operator is merely required to load and unload his fixtures. E.P.R.

Wheel selection. ANON. *Abrasive Ind.*, **10** [7], 15 (1929).—Cast iron, brass, aluminum, and materials of low tensile strength require wheels made of a brittle abrasive such as silicon carbide, which is manufactured under various trade names. The bond may be vitrified, silicate, elastic, or rubber. For most purposes the vitrified bond is best. Steel or materials of high tensile strength require wheels made of a tough abrasive such as manufactured alumina, which is made from bauxite. Silicate bond is best where the time is limited for making up the wheels. Also it is used for certain classes of work, such as knife grinding, or on certain types of surface grinders. E.P.R.

Exhaust system promotes clean surroundings; reduces fire hazard. B. K. PRICE. *Abrasive Ind.*, **10** [7], 46–50 (1929).—The problem of exhausting abrasive grit, acid and lacquer fumes from metal finishing departments has been given considerable attention of late years. Lacquer rooms in particular must be ventilated adequately to lessen fire hazards. This article illustrates and describes an up-to-date system recently installed in one of the plants of the Otis Elevator Co., N. Y. E.P.R.

Grinding art in American textile machinery. HERBERT R. SIMONDS. *Abrasive Ind.*, **10** [7], 11–15 (1929).—S. illustrates and describes a number of interesting grinding operations performed in the manufacture and maintenance of textile machinery. The use of special devices results in a high degree of accuracy on what ordinarily would be termed very difficult abrasive engineering problems. E.P.R.

New abrasive organization. ANON. *Abrasive Ind.*, **10** [7], 32 (1929).—The Durex Abrasives Corp., one of the most powerful and far-reaching combinations for export, has just been organized to cut costs and improve mechanical sanding operations in a great variety of industries throughout the country. The corporation includes nine important companies in the abrasive field. E.P.R.

Diamond mining in Brazil. SYDNEY H. BALL. *Min. and Met.*, **10** [270], 282–85 (1929).—Historical notes on diamond mining in Minas Geraes, Brazil are presented. F.P.H.

BOOK

Complete Equipment for High-Speed Snagging. Released by Norton Co., Worcester, Mass., 16 pp., illus.; reviewed in *Abrasive Ind.*, **10** [7], 26 (1929).—It is pointed out that great strides have been made during the past years in applying higher grinding wheel speeds to miscellaneous snagging operations and that surface speeds as high as 9000 ft. per min. are now employed. Bakelite snagging wheels are described and a cross-section of a wheel with two reinforcing steel rings is shown. Unicast snagging wheels are also illustrated. E.P.R.

PATENTS

Reclamation of abrasive materials. SAMUEL F. WALTON. U. S. 1,718,264, June 25, 1929. As a reclamation process for separating the bonded grains of abrasive or refractory scrap from their bond, the method consisting in heating the scrap and in suddenly cooling to render the bond relatively friable, and in mulling to reduce the bond to a separable state.

Hydraulic grinder. JAMES E. GREENSMITH. U. S. 1,718,554, June 25, 1929. In combination, a tool, hydraulically actuated means for reciprocating the tool across work, a work support, means for rotating the work support, means under control of the tool actuating means for feeding the work toward the tool at the end of the movement of the tool in either direction of its reciprocating travel, means for rotating the tool as it traverses the work, and a valve under control of the tool actuating means for automatically effecting the reversal of movement of the tool.

Preparing aluminous materials. RAYMOND R. RIDGWAY AND JOHN B. GLAZE. U. S. 1,719,131, July 2, 1929. As a new article of manufacture a solidified aluminous product comprising crystalline alumina grains of high purity, in association with reduction products of alumina and with aluminum sulphide, the proportion of sulphide not substantially exceeding 3% by weight of the mass, the product undergoing disintegration when subjected to hydrating conditions.

Grinding attachment for lathes. PHILIP H. BUEHRLE. U. S. 1,719,689, July 2, 1929. In combination with the compound slide of a lathe, a base member fixed to the compound slide, a motor support pivoted to the base member, a driven rotatable shaft journaled in opposed bearings in the motor support, an electric motor mounted on the motor support, aligned pulley wheels mounted on the driven rotatable shaft and the drive shaft of the electric motor, a belt passing over the aligned pulleys, and a handle member on the motor by which the same and the motor support may be tilted about the pivot point of the latter.

Grinder for timers. CHARLES D. PRICE. U. S. 1,719,725, July 2, 1929. In a device of the character described, an abrading element, means for mounting the abrading element for rotation including a shaft having a lateral flange and a sleeve provided with a flange and a disk-like stop member rotating with the abrading element, the stop member having a central hub portion engaging a side face of the abrading element and mounted between the lateral flange of the shaft and the sleeve flange, and a relatively wide peripheral flange portion offset from the hub portion to space the flange portion axially from the plane of the abrading element.

Grinding machine. MORTIMER G. ROSS. U. S. 1,719,784, July 2, 1929. In a grinding machine or mill, including a pair of grinding plates mounted in confronting relation, one of the plates being mounted eccentric to the other and eccentric to its own mounting.

Grinding machine. PAUL BRÜHL. U. S. 1,719,964, July 9, 1929. A grinding machine comprising grinding means defining a plurality of passages, sets of push bars allotted to sets of the passages, means for reciprocating the sets of push bars in the passages, and transverse feeding means at either end of the passages adapted to receive

the blanks from the passages and to move them forward through the pitch of the passages. U. S. 1,719,965, July 9, 1929. A grinding machine comprising a pair of grinding plates, each plate defining a part of a passage, means for feeding blanks through the passage, and means for separating and bringing together the plates.

Gear-grinding machine. CHARLES H. SCHURR. U. S. 1,720,404, July 9, 1929. The combination of a base, a carriage movable thereon, a spindle rotatably carried by the carriage, a blank carried by the spindle and rotatable therewith, a tool disposed in the path of movement of the blank, indexing means to advance the blank when the carriage has reached a predetermined position on the base, means for imparting a rolling movement to the blank during the movement of the carriage, the last-named means including a rack and a gear carried by the spindle and adapted to roll along the rack during the movement of the carriage, and mechanism operable to move the rack into and out of the path of travel of the gear.

Loading device for grinding machines. EDWARD A. BAYTON. U. S. 1,720,620, July 9, 1929. A work holder and a toothed work-piece are first assembled and then mounted in a machine tool, means for determining the position of the work-piece in the machine, comprising a machine engageable element on the holder, means for positioning the work-piece on the holder with a tooth thereof in a predetermined position relative to the machine engageable element comprising structural elements of the holder permitting relative movement between the engageable means and the work-piece, means on the holder for fixing the work piece and machine engageable element in the relative position, and an auxiliary assembling device for locating the work-piece and machine engageable element in the relative position.

Grinding machines. VAN NORMAN MACHINE TOOL CO. Brit. 309,402, June 6, 1929. The wheel slide of a grinding machine is supported on a base and is adjustable relatively to a second slide supported in the base. In order to position and lock the slide, after retraction for replacement of the work, it is moved through a rack and a pinion by a lever until an adjustable screw on the slide contacts with an abutment on the base, accurate positioning and avoidance of strain being achieved by the use of a second and adjustable stop on a lug on the base, which is struck by a stop on the lever at the same instant that the stop encounters the abutment. The lever is locked in its lowest position by a latch plate adapted to engage under a plate on the base, and carried by a spring pressed handle on the lever. A spring serves to check the speed at which the lever is moved when it nears the end of its motion.

Centerless grinding machines. CINCINNATI GRINDERS, INC. Brit. 309,412, June 6, 1929. In grinding work-pieces having portions of different diameters, such as drills, in a centerless grinding machine, each work-piece is supported outside the grinding throat while one portion is being ground and this ground portion is then supported outside the throat of a second machine while the previously supported portion is being ground concentrically with the first-formed portion.

Centerless grinding machines. CINCINNATI GRINDERS, INC. Brit. 309,413, June 6, 1929. A centerless grinding machine has a work-supporting fixture adjacent the grinding throat which may be swung from a work-receiving position into a position where a projecting part of the work extends into the throat.

Band grinding machines. C. H. HAY AND R. C. PORTWAY. Brit. 309,677, June 6, 1929.

Grinding convex surfaces. W. OSBERGHAUS. Brit. 309,806, June 12, 1929. Convex surfaces, *e.g.*, the edges of double-edged razor blades, are ground by an abrading surface on the interior of a hollow cylinder, the blades being moved or reciprocated parallel to the axis of the cylinder, so as to pass right through the cylinder.

Internal grinding machines. RANSOME & MARLES BEARING CO., LTD. AND J. D.

SCAIFE. Brit. 310,085, June 12, 1929. In a machine for grinding ball races, etc., internally, feeding means for the work or the grinding wheel are provided whereby the rate of feed diminishes from a coarse commencing feed and finally ceases when the work is to size; means for truing the grinding wheel prior to the finishing cuts are also provided.

Grinding knife-edge bearings. H. D. FITZPATRICK. Brit. 310,251, June 12, 1929. A machine for grinding knife-edge bearings arranged in spaced relation on a part so as to form a group, as used in weighing-scales, consists of a bed provided with guides for a reciprocatory frame, upon which the parts carrying the knife-edges are mounted by clamps.

Centerless grinding machines. F. G. HEARD. Brit. 310,782, June 26, 1929. A machine for grinding the external surface of cylindrical work, or of tubular work concentrically with the bore, consists of a control wheel carried by a head pivoted on a base, and pressed toward the work by a spring, and a grinding wheel carried by a head pivoted to the base and having a downwardly extending weighted arm. The work, or a mandrel carrying it, is supported between the wheels by a rest having a notch shaped to prevent lifting of the work by the wheel. In a modification, the work rest is pivotally mounted, and is movable about its pivot to an extent limited by two stops.

Abrasive tools. CARBORUNDUM CO., LTD. Brit. 310,841, June 26, 1929. Abrasive and refractory articles are rendered less permeable and more durable by impregnating the bonding material with a heat-resisting substance. The article may be impregnated with aluminum hydroxide and/or calcium hydroxide, preferably by impregnating with a solution of the chlorides and treating with ammonia solution or gas, or with aluminium sulphate, and heated to deposit the corresponding oxides. The impregnating solution, *e.g.*, is a saturated solution of aluminium chloride 10 parts, and calcium chloride 1 part. Other impregnating materials such as solutions of alkali silicates or other salts or clay suspensions may be used.

Grinding pistons, etc. BOHN ALUMINUM & BRASS CORP. Brit. 310,921, June 26, 1929. A hollow cylindrical article, *e.g.*, a piston, is ground so that at one end it is slightly smaller on one diameter than on a diameter at right angles thereto, this result being achieved by providing, during grinding, a less firm support at the parts which are to have the greater diameter, so that the parts spring inwardly and are ground to a less extent. The piston, consisting of a head and a skirt, is mounted on a rotating center having a driving-pin, the center having cut out parts to allow the piston to spring, and a spring-pressed center supporting the piston at its closed end. Instead of using a center with cut-out parts, the center may be circular, and the piston has ribs at its open end adapted to rest on the center, the ribs having gaps so that the piston is unsupported at the gaps.

Grinding pistons, etc. BOHN ALUMINUM & BRASS CORP. Brit. 310,951, June 26, 1929. A hollow cylindrical article, *e.g.*, a piston, is ground to a slightly oval shape by expanding one end to an oval exterior shape, grinding the exterior surface to a true cylindrical shape, and then releasing the expanded end. In a modification, the interior of the open end of the piston is given an oval shape, and the piston is pressed on to a circular center.

Centerless grinding machines. V. A. B. HUGHES. Brit. 311,026, June 26, 1929. In a centerless grinding machine for work-pieces of small diameter having pointed ends, blanks are fed automatically from a shoot to the throat between a grinding wheel having a centrally recessed peripheral face with projecting side flanges and a plane regulating wheel which has a bevelled edge to facilitate entry of the blanks. A shoot filled with prepared blanks is inserted in the machine, and is located by a groove and projection on the machine and secured by an eccentric operated by a hand lever. The front of the shoot is provided with sight apertures for observation of the position of

the blanks. The blanks are prevented from falling out of the shoot during insertion by means of a dog on a spring projecting into the guideway, the construction being such that on insertion the spring is deflected by a corner of the bracket on the machine to withdraw the dog and allow the blanks to fall on a catch. A slide is reciprocated to and from the shoot to feed a blank to the grinding throat by means of a plunger, and also to actuate the catch by means of cam surfaces carried thereby.

Grinding attachments for lathes. BARLOW & CHIDLAW, LTD. AND A. S. ROWLEY. Brit. 311,057, June 26, 1929. In a lathe attachment for grinding screw-threads, worms, or gear teeth, the top member of a compound cross-slide carries a swiveling bracket which is adjustable around the axis of a shaft which carries a bevel wheel, driving a bevel wheel on the spindle of the grinding wheel. For grinding worm threads the cross-slide is set at an angle of $14^1/_2°$ and the bracket is tilted to an extent indicated on a scale in accordance with the lead of the thread.

Rubber-bonded abrasive articles. CARBORUNDUM CO., LTD. Brit. 311,104, June 26, 1929. Rubber-bonded abrasive articles are made by mixing abrasive particles with a rubber dispersion, and coagulating the rubber to form a bond. The dispersion may be natural latex, thickened, concentrated, or curdled, or an artificially prepared dispersion. Suitable compounding ingredients may be added; *i.e.*, a composition comprises 70 parts abrasive grains, such as silicon carbide or aluminium oxide, 4 parts sulphur, 26 parts latex, and glue to form 10% by weight of the mixture. The rubber is coagulated, *e.g.*, by adding acetic acid or alum, or by heat, and the composition is molded and vulcanized.

Cylinder grinders. M. C. HUTTO. Brit. 311,138, June 26, 1929. In a cylinder grinder consisting of abrading members adjustable radially of a body by cones acting on pins, riveted to the holders of the abrading members, the holders consist of channel-section metal stampings and the member is secured therein by solder or other self-hardening material. In operation the tool is rotated and reciprocated in the cylinder, the mounting of the cones, etc., allowing the members to adjust themselves to the cylinder, and finally to assume a correct position parallel to the axis.

Art

Manufacture of mosaic glass. W. SELESNEFF. *Trans. Ceram. Res. Inst.* [U.S.S.R.], **10,** 1–80 (1928).—A detailed description of manufacturing mosaic glass, use of coloring materials, influence of different ingredients of the mosaic glass batches, as well as the methods of work and the conditions of melting are given. Special manipulations and tricks used in manufacturing colored glass are mentioned. S. directed the work of the mosaic glass factory at the Academy of Art in Russia for 36 yrs., giving much value to his knowledge of the question. The following chapters are listed: I. Composition and Properties of Batches. II. White Lead, Its Composition and Properties. III. Colored Alloys. IV. Practical Process of Preparing Batches. V. Colored Batches. VI. Gilded Batches. VII. Red Copper Batches. W.A.

Copper ruby glaze. II. TOSAKU YOSHIOKA AND SHO HIRAOKA. *Jour. Jap. Ceram. Assn.*, **36** [424], 154–60 (1928).—This report deals with the results obtained from a study on the influence of the addition of a different auxiliary agent to a base glaze

$$\left.\begin{matrix}0.25Na_2O\\0.15K_2O\\0.60CaO\end{matrix}\right\}\ 0.25Al_2O_3\ \left\{\begin{matrix}3.0SiO_2\\0.25B_2O_3\end{matrix}\right.$$

upon its color. *I. Influence of Auxiliary Colorants:*

$$\text{Frits}\ \left.\begin{matrix}0.25Na_2O\\0.15K_2O\\0.60CaO\end{matrix}\right\}\ 0.25Al_2O_3\ \left\{\begin{matrix}3.0SiO_2\\0.25B_2O_3\end{matrix}\right. + 1\%\ \begin{matrix}CuO\\SnO_2,\end{matrix} + (1\text{–}5)\%\ Fe_2O_3,\ PbO,$$

or ZnO were prepared with a heavy oil kiln and were reheated in an atmosphere of N_2 or CO_2 at 600, 700, 800, or 900°C for 1 hr. Results: (1) PbO and ZnO seem to counteract to the production of red; (2) both Fe_2O_3 and SnO_2 give deep ruby reds in N_2 and CO_2 atmosphere; (3) SnO_2 gives more beautiful reds than Fe_2O_3; (4) the suitable amount of the oxides ranges from 2 to 4%; (5) the best reheating temperature is 700°; (6) CO_2 produces reds at lower temperature than N_2, though they are not so clear as those obtained in N_2. *II. Effect of Reduction:* The same frits containing 2 to 4% SnO_2 prepared in an atmosphere of N_2 and reheated in the same gas at 700° or 800° had red colors, though they were lighter than those described in *I*. The same frits containing 1 to 5% SnO_2 were prepared from batches, to which a theoretical amount of cane sugar required for the reduction of CuO to Cu_2O had been added, in an atmosphere of N_2. The frits were greenish when cooled quickly and deep red if cooled slowly. Deep red frits were obtained by reheating the frits containing 2 to 4% SnO_2 at 700°. *III. Effect of Time of Reheating:* Too long heating gives the frits brownish tints and makes them opaque, and such time is influenced by the content of SnO_2. S. K.

Enlarging and reducing shapes of vessels by linear and volumetric measure. JOSEF WOLF. *Sprechsaal*, **62** [20], 349–51; [21], 369–71 (1929).—Numerous illustrated examples are given and graphic as well as algebraic methods are employed for the solution. T.W.G.

Effect of basic fluxes on metal oxide colors. ANON. *Keram. Rundschau*, **35**, 555 (1927).—Experiments were carried out on 18 glazes containing alumina and no boric acid and on 14 glazes containing boric acid and little or no alumina. The coloring oxides used were NiO, Cr_2O_3, Sb_2O_3, CoO, and Fe_2O_3. The results are given in tables. (*Trans. Ceram. Soc.* [Eng.])

Copper ruby and red glass. A. GRANGER. *Ceram. Verrerie*, **49**, 35 (1929).—A review of the literature. Recipes are quoted. (*Trans. Ceram. Soc.* [Eng.])

Potter's wheel products. LEONORA DELIMA ANDREWS. *Amer. Home*, **2** [5], 564 (1929).—Advantageous use of pottery in decoration is discussed. The various types of ware that can be found on trips through crockery departments are described briefly. E.J.V.

Low-priced glassware. LEE MCCANN. *Amer. Home*, **2** [5], 580 (1929).—A discussion on what can be done with a small amount of money when properly spent, the various glass and pottery articles which make for beautiful decorative effects in the home and in table settings being enumerated and their low prices given. E.J.V.

Royal Society of Arts competition of industrial designs. ANON. *Chem. News*, **138**, 412 (1929).—An interesting innovation this year in the pottery and glass section was the entry of 140 actual specimens of fired pottery instead of designs. Offers of prizes for the 1930 competition have already been received from important manufacturers. H.H.S.

Marianna von Allesch, glass blower. R. F. *Christian Sci. Mon.*, **21** [181], 8 (1929).—Among the latest novelties in glass to find their way to the American market are the figures of Marianna von Allesch, Thuringian glass blower, master craftsman, and artist. E.J.V.

Pythagoras ware. J. D. FULTON. *Chem. and Ind.*, **48**, 663 (1929).—A British criticism of the new German ware. F. found tubes made of this ware for use in an electric furnace to be badly shaped, to crack after four days use, and to be nonuniform at the fracture. A British ware under similar conditions was entirely satisfactory. H.H.S.

Porcelain presents. ANON. *Illus. London News*, **173**, 1088 (1928).—The Prussian Government, in order to encourage large families, is presenting to all parents who have

twelve children a handsome cup and saucer specially made at the Prussian State Porcelain Factory, worth about $50. The decoration includes a mother with children and a rosebud design. H.H.S.

Porcelain chessmen from Leningrad. ANON. *Asia*, **29**, 568–569 (1929).—Designs of a Bolshevized set of chessmen made at the State Porcelain Works at Leningrad are shown. A king and queen symbolizing Death and Extravagance are opposed by a workman as king and a peasant girl as queen, and so on for the other pieces. H.H.S.

Ceramics of Nove. M. STECCO. *Faenza*, **15**, 47 (1927).—A historical sketch is given of the ceramic industry of Nove, near Bassano (Vicenza).
(*Trans. Ceram. Soc.* [Eng.])

American Indian Museum (Heye Foundation). C. M. B. CADWALADER. *Science*, **69**, 543 (1929).—The Museum has acquired the entire collection of the Philadelphia Academy of Natural Sciences relating to the archaeology and ethnology of the American Indian. The transfer includes the Clarence B. Moore, A. H. Gottschall, and S. S. Haldeman collections. H.H.S.

Abo's seventh centenary. ANON. *Christian Sci. Mon.*, **21** [193], 9 (1929).—An engraved covered crystal bowl was exhibited at the Fair held in Abo (Finland), in celebration of its 700th anniversary. The bowl, which is valued at 150,000 M, is the work of the Karhula firm. Many months were spent on its engraving. This specimen was presented to King Alfonso at the Barcelona Fair. The Karhula firm also presented a crystal cup worth 50,000 M to the city of Abo in honor of its seventh century. E.J.V.

Historic stained glass. ANON. *Christian Sci. Mon.*, **21** [198], 9 (1929).—Eight 16th Century panels, in pairs, of early stained glass were recently sold in London for a price of about $12,500. They were imported from Germany hundreds of years ago and are decorated with life-size figures. The mellowing effect of age on the colors, the pitted surface, the speckling with air bubbles, and the designs, all proved their authenticity, apart from their known pedigree. E.J.V.

New discoveries at Beisan. ALAN ROWE. *Illus. London News*, **173**, 1093–95 (1928).—An account is given, with 11 illustrations, of the 1928 work of the Museum of the Univ. of Pa. The foundations of a *Migdol* (fort-tower) were discovered and yielded valuable finds, among them a potsherd with hieratic inscription, a "toby-jug" of the dwarf god Bes shaped as a squatting man, bricks with impressions of the reeds on which they were put to dry, and amulets, figurines, etc. Beth-Shan keeps up its reputation of being one of the richest tells so far excavated in Palestine. H.H.S.

Mosaics in early Christian churches. A. H. M. JONES. *The Times*, June 8, 1929.—Mosaics of fine quality and high interest have been found at Jerash in three churches excavated by the joint expedition of Yale Univ. and the British School of Archaeology at Jerusalem. H.H.S.

The potter in the Bible (anthology). ANON. *Faenza*, **15**, 57 (1927).—Eight Latin quotations are given with the Italian equivalents. (*Trans. Ceram. Soc.* [Eng.])

Technical ascent of man. WALDEMAR KAEMPFFERT. *Sci. Monthly*, **28**, 481–98 (1929).—An account is given of the foundation and exhibits of the Rosenwald Industrial Museum at Chicago. H.H.S.

Prehistoric female figurines. E. B. RENAUD. *Sci. Monthly*, **28**, 507–12 (1929).—An illustrated account of the finds of statuettes in America and the Old World, showing that "the first god was a goddess." H.H.S.

Belgian research in Syria. ANON. *The Times*, June 12, 1929.—The first Belgian archaeological excavations abroad are being financed by Government credits and a grant from the National Fund of Scientific Research. It will carry out researches at Apamea in Syria under the direction of Prof. Mayence of Louvain. H.H.S.

Origin of majolica. G. BALLARDINI. *Faenza*, **15**, 29 (1927).—An illustrated review of B. Rackham's work: "Early Netherlands Majolica," describing the origin of majolica in the Netherlands and in England is given. (*Trans. Ceram. Soc.* [Eng.])

Faiences of Moustiers. ANON. *Ceram. Verrerie*, **49**, 9 (1929).—A note on the old industry which flourished between 1680 and the beginning of the reign of Louis XVI. (*Trans. Ceram. Soc.* [Eng.])

Ceramics of the Sigmaring collections. W. SCHÜRMEYER. *Sprechsaal*, **62**, 4 (1929).—A description is given of the collection, and a number of Hispano-Moresque and old Italian and German pieces are illustrated. (*Trans. Ceram. Soc.* [Eng.])

Chinese neolithic urns. ANON. *The Times*, June 10, 1929.—The British Museum has acquired by gift of the Ostasiatiska Samlingarna of Stockholm some neolithic urns of the third millennium B.C. excavated by the Director in Kansu. The find is regarded as of great importance for the relations it suggests between the neolithic culture of N. W. China and the contemporary arts of the Near East. H.H.S.

Chinese pottery of the Sui dynasty. ANON. *Illus. London News*, **173**, 1091 (1928).—A full-page illustration of a magnificent example of 6th Century Chinese art, in the form of a horse modelled in unglazed grey pottery, with traces of orange coloring remaining on the trappings. Height $13^1/_2$ inches with wood stand, length 11 inches. The beauty and power of the modelling suggests that it was executed for the first Sui emperor, Yang Chien's private collection. H.H.S.

Canton enamels. E. F. STRANGE. *Illus. London News*, **173**, 1100–1108 (1928).—The wheel of fashion is said to be making a turn away from the enameled porcelains of the 18th Century and toward the enamels on copper known as Canton. Their inspiration came from the painted enamels of Limoges, and they are known to the Chinese as *yang tz'u* ("foreign porcelain"), just as the *famille rose* group of colors are known as *yang ts'ai* ("foreign colors"). Four illustrations. H.H.S.

Program of the summer courses at Faenza (2nd Year). (Catalog of Italian Inter-university Institute, 1929.)—Promoted by International Ceramic Museum at Faenza. Covering the history of Italian ceramics in the middle ages and modern times, the course is divided into (*a*) general curriculum, emphasizing sources and technique, (*b*) special school, taking up special workers or places, (*c*) Italian influence, centering around art stores, (*d*) Italian porcelains, (*e*) collections of ceramics in Italy, (*f*) collections of Italian ceramics abroad, (*g*) modern tendencies, (*h*) didactic exhibitions of special interest, (*i*) practical workshop and technical demonstrations, all except one given in Italian, and illustrated. There are also organized excursions to Ravenna, to Pesaro and Urbino and to Predappio. The course was given from June 27 to July 25. E.B.H.

BOOKS

Art Judgment Test. CARL E. SEASHORE. *Science*, **69**, 380 (1929).—The Meier-Seashore test book published by the Univ. of Iowa at $1.00 marks the introduction of scientific procedure into the new field of analysis and measurement of art talent. H.H.S.

The Fallen Idols. M. L. SOLON. London and Beccles: William Clowes & Sons, Ltd. Price 5s net; reviewed in *Pottery Gaz.*, **54** [625], 1134–35 (1929).—This volume consists of a series of papers read by S. over 30 yrs. ago. (1) Describes the history of the manufacture of Buccaros articles in scented, porous pottery by the Latin races in the 15th, 16th, and 17th Centuries. (2) Deals with the legendary jugs of "Countess Jacqueline." The jugs were used for drinking one toast and then smashed. They were found in the moats of Teylinger centuries later. (3) Deals historically with the earthenware mortuary lamps buried with the ancients. (4) Deals with the mystical Murrhine vases of the Roman period, probably made in vitreous paste. (5) Deals

with the origin of old Celadon ware, and traces its development in different countries and centuries. (6) About 30 pages dealing with "Fossil" pottery. (7) "Terra Sigillata," deals with health-giving clay which was converted into pots, first in the East and later in western Europe, the forerunner of kaolin or china clay. E.J.V.

Lovelock Cave. L. L. LOUD AND M. R. HARRINGTON. Univ. of Calif. Press, Berkeley, Calif., 1929. 183 pp., 93 illustrations. Price $2.50.—A report is given of the expedition sent out under the auspices of the Univ. of Calif. and the Museum of the American Indian on the rich cultural life of a tribe that lived about 1000 B.C. in the Humboldt Mts. of west-central Nev. H.H.S.

Old Civilizations of the New World. A. HYATT VERRILL. Illus. Bobbs-Merrill Co., 1929. pp. xvi + 393. Price $5.00.—An account of the cultures and civilizations of the Mayas, Aztecs, Incas, and other races is given. H.H.S.

Early Church Art in Northern Europe. JOSEF STRZYGOWSKI. Batsford, 21s net; reviewed in *Brit. Clayworker*, **38** [446], 96 (1929).—S. shows that good brickwork was a feature of the architecture of northern Europe at a much earlier period than has generally been assumed. It was not derived from Mediterranean culture, but was of independent origin. Illustrated. R.A.H.

Civilization of Greece in Bronze Age. H. R. HALL. Methuen & Co., London, 1928. Price 30s.—The culture migration from Egypt to Crete, and from Crete to Greece as proved by the pottery, gold work, signets in various materials, and other finds, is described. The native pottery under the influence of Egypt is said to have been "crude in fabric but attractive in shape and, in the case of mottled ware, in color as well." Reviewed in *Times Lit. Supp.*, **27** [1399], 877 (1928). H.H.S.

PATENTS

Design for a bottle. ABRAHAM LEVY. U. S. 78,826, June 25, 1929; ALBERT E. SIERAD AND MILTON SIERAD. U. S. 78,844, June 25, 1929; ERNEST DALTROFF. U. S. 78,878, July 2, 1929; GEORGE N. MAS. U. S. 78,934, July 9, 1929; WILLIAM E. SWINDELL. U. S. 78,949, July 9, 1929 (reissues).

Design for a plate, etc. DANIEL GALE TURNBULL. U. S. 78,907, July 2, 1929 (reissue).

Design for footed tumbler, etc. GEORGE S. DUNBAR. U. S. 78,912, July 2, 1929 (reissue).

Design for glass goblet. WILBER L. ORME. U. S. 78,896, July 2, 1929 (reissue).

Design for compote, etc. ROBERT E. MCELDOWNEY. U. S. 78,835, June 25, 1929 (reissue).

Cement, Lime, and Plaster

Unsoundness factor in Portland cement manufacture. ALTON J. BLANK. *Rock Prod.*, **32** [14], 72–74 (1929).—Unsoundness of Portland cement can be attributed directly to the presence of excessive qualities of "free" or uncombined lime. A number of causes of free lime rank in importance as follows: (1) underburning, (2) poor chemical control of raw mixtures, (3) insufficient grinding of raw mixtures. There is no relation between the free lime and expansion. Neither do the cements having the smallest percentages of free lime present give the best tensile strengths. It would appear that varying percentages of free lime, (0.34% to 1.68%) are not factors in the short-time tensile strengths. By finer grinding of the raw materials, more uniform chemical control of these mixtures, and more complete clinkering the free lime content can be kept at a minimum. Before going to the expense of meeting these requirements, however, it will be necessary to definitely show just what detrimental effect $^1/_{10}$ of 1% of free lime, or even 1%, may have on the ultimate quality of concrete. F.P.H.

Free lime in clinker and cements. E. DIEPSCHLAG AND A. MATTING. *Zement*, **17** [35], 1306–1308; [36], 1337–40; [37], 1373–76 (1928); *Rock Prod.*, **32** [13], 82

(1929).—A review of the researches on this subject is given with 129 references dating from 1823 to 1926 in English, French, and German. These deal with the presence of free lime and its causes; methods for determination of free lime, such as methods in aqueous solution, nonaqueous mediums of solution and optical methods; investigations for determining free lime, dealing with testing of $CaCO_3$ and CaO, melting of $2CaO \cdot SiO_2$, tests with $CaO \cdot SiO_2$ and $2CaO \cdot SiO_2$, tests with clinker, testing with water without carbonic acid, microscopic testing, and with the titration process with ammonia acetate. F.P.H.

Chemical test methods and sulphate resistance of different brands of Portland cement. GEORGE W. BURKE. *Rock Prod.*, **32** [12], 79–80 (1929).—Various brands of Portland cement hydrolyze and liberate lime at different rates when treated with an excess of water and the rate and extent of the lime liberated does not specifically indicate the sulphate resistance of cement or the extent of chemical reaction in sulphate solutions. The relative rate and extent of chemical reaction as caused by sulphate solution does not truly indicate the relative resistance to sulphate waters. It is probable that a general idea of the sulphate resistance of various brands of Portland cement can be quickly ascertained by submitting briquets, all made in the same manner, to solutions of sodium sulphate of 10 to 15% concentration. F.P.H.

Cement improvement. H. RICHARZ. *Zement*, **17** [42], 1540–42 (1928); *Rock Prod.*, **32** [12], 94 (1929).—R. discusses a few problems important for practical work, considering concrete and its raw materials, cement aggregates and water and their preparation, in which the bettering of cements comes under cement improvement, and developments in conditions and use of aggregates, and mixing water and the method of concrete mixing under concrete improvement. After briefly describing the manufacture, composition, and development in standard cements, R. presents the two purposes in cement improvement as being (1) improving of the qualities of the cements in general, and (2) making cements suitable for certain specific applications. The history of the attempts to improve the qualities of different cements by various methods or additions is reviewed; the references given date back to 1879. F.P.H.

The quality of Portland cement by chemical methods. ARTHUR J. POOL. *Rock Prod.*, **32** [13], 59–60 (1929).—The procedure used and the results obtained from an original chemical method for estimating the 7-day tensile strength of Portland cement have been described. The results appear to indicate that a relationship exists between the 7-day tensile strength of 1:3 standard mortar briquets and the amount of lime extracted from the cement by a definite amount of water under definite conditions. F.P.H.

Criticism of the standard cement strength tests. BERTEL GEITLIN. *Rock Prod.*, **32** [13], 43–46 (1929). F.P.H.

Tests on cement kilns. H. STEHMANN. *Tonind.-Ztg.*, **53** [17], 333–35 (1929).—S. reviews the testing of cement kilns by the kiln commission of the German Assn. of Cement Mfrs., with special reference to the rotary kiln equipped with the Stehmann system. S. suggests that in future tests various sources of possible losses be checked, such as high waste gas temperature, hot clinker at the kiln discharge, unsuitable coal, incomplete clinkering, and that a heat balance of the kiln would be useful. He concludes with an enumeration of the advantages of the Stehmann system. F.P.H.

Fundamentals of shaft-lime kiln. OTTO K. SCHAEFER. *Rock Prod.*, **32** [12], 55–56 (1929).—A discussion of V. J. Azbe's paper on the "Ultimos" kiln published in *Rock Products*, June 12, 1926. F.P.H.

Reference laboratory for Portland cement. ANON. Bur. Stand., *Tech. News Bull.*, No. 146, pp. 54–55 (1929).—An important recent development is the establishment at the Bureau of a reference laboratory for the testing of Portland cement, cali-

bration of machines and instruments used in cement testing, and the training of men for commercial cement-testing laboratories. The new laboratory is supported jointly by the A.S.T.M. and the Federal Government. Tests will be made of Portland cement in strict conformance with the standard specifications and tests of the A.S.T.M., and at present will be confined to physical testing. R.A.H.

Dressing quartziferous sands for manufacturing glass. B. I. ROSOFF AND A. I. KITAIGORODSKY. *Ceramics and Glass* [U.S.S.R.], **2,** 46–49 (1929).—A description of tests performed in the Laboratory of the Mining Academy, U.S.S.R., as to the dressing of quartziferous sands is given. Most of the sands used for manufacturing glass contain alumina, lime, iron oxides, alkali, and titanium, as well as organic admixtures. Elimination of iron oxides was the main problem to be solved by the tests. Petrographic examination proved that the sands contained iron in the form of (1) iron-oxide laminae, which could not be easily separated from the grains of quartz; (2) separate grains of limonite or in the form of cementing material binding single grains, and (3) separate grains of magnetite, ilmenite, and spinel. The following methods were used for removing iron: (1) a preliminary separation of small pieces richest in iron; (2) dressing by the wet process in concentration tables; and (3) dressing by magnetic separation. Tables show results obtained at each step. W.A.

Tests on Japanese cement. V. SHOICHIRO NAGAI. *Jour. Jap. Ceram. Assn.*, **36** [423], 104–13 (1928).—The result of the tests on Japanese Portland cements, manufactured in 1927 is compared with those in previous reports (Table I).

TABLE I. STRENGTHS OF 1:3 MORTARS AND FINENESS OF CEMENTS

		Av. tensile strength			Av. compressive strength			
		Days (kg./sq. cm.)						Residue on 4900-mesh sieve (%)
	Date	3	7	28	3	7	28	
(1)	March, 1924		24.8	31.0		259	360	10.04
(2)	May, 1926		27.0	33.2		338	435	8.14
(3)	May, 1927	26.3	28.7	32.2	329	437	531	3.04
(4)	Nov., 1927	25.9	28.7	32.9	335	452	572	1.82

Tests on Japanese cement. VI. SHOICHIRO NAGAI. *Jour. Jap. Ceram. Assn.*, **36** [426], 265–75 (1928).—Long-age strengths and chemical analysis of the cements, manufactured in 1927 and described in the second report, are given (Tables I and II).

TABLE I. LONG AGE STRENGTHS OF 1:3 MORTARS

	Tensile strength			Compressive strength		
	Weeks (kg./sq. cm.)					
	8	13	26	8	13	26
12 Jap. Portland cements	30.1–37.3	30.8–40.2	31.8–41.3	510–636	540–643	572–676
Average	34.6	36.6	37.3	565	593	612
Velo cement	38.2	39.9	40.5	686	701	733
Blast-furnace cement	37.0	38.0	40.7	561	594	644
Soliditit	34.0	35.5	36.6	486	520	538

TABLE II. CHEMICAL COMPOSITION

	Ignition loss	Insoluble residue	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	SO_3	Sulphide sulphur	Alkalis
(1)	1.02	0.25	21.87	5.58	3.12		65.60	1.28	1.30		
(2)	2.59	2.56	20.37	6.75	2.43		63.57	1.17	2.78		
(3)	0.74	0.78	26.53	8.24	3.14	1.00	54.86	1.34	1.28	0.65	2.12
(4)	1.67	12.80	31.51	7.26	2.66		51.59	1.77	1.70		1.80

(1) Average of 12 Jap. Portland cements, (2) Velo cement, (3) blast-furnace cement, and (4) Soliditit. Table I shows that recent Japanese Portland cements are losing their long-age strengths owing to increase in fineness. The relation between their chemical composition and strengths are discussed. S.K.

Tests on Japanese cement. VII. SHOICHIRO NAGAI. *Jour. Jap. Ceram. Assn.*, **36** [429], 440–48 (1928).—The results of long age test, chemical analyses, and various indices or ratios between constituents of cements manufactured in 1927 and described in the 5th Rept., are given:

TABLE I. LONG AGE STRENGTHS OF 1:3 MORTARS

	Tensile strength Weeks (kg./sq. cm.)			Compressive strength Weeks (kg./sq. cm.)		
	8	13	26	8	13	26
12 Jap. Portland cements	30.2–41.0	30.9–42.2	31.7–42.9	542–706	553–732	563–741
Average	34.9	36.1	37.2	616	649	666
Ferro-concrete	41.6	42.8	44.3	641	694	718
Lumnite	31.9	35.0	37.1	649	673	695

TABLE II. CHEMICAL ANALYSIS

	Ignition loss	Insoluble residue	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3
Av. of 12 Jap. Portland cements	1.05	0.38	21.52	5.17	3.64	65.55	1.37	1.21
Ferro-concrete	2.39	0.48	21.36	5.50	2.65	65.00	1.18	1.66
Lumnite	2.94	2.86	8.03	38.92	6.82	38.06	0.96	0.68

S.K.

Tests on Japanese cement. VIII. SHOICHIRO NAGAI. *Jour. Jap. Ceram. Assn.*, **36** [430], 475–83 (1928).—N. reports the results of tests on 19 Japanese Portland cements, a blast-furnace cement, a Soliditit, all collected at Tokio and Osaka markets in April, 1928, Velo cement (Denmark), Special cement (Germany) and Super-cement (England). Strengths of 1:3 mortars are shown in Table I.

TABLE I. STRENGTHS OF 1:3 MORTARS
(Kg./sq. cm.)

	Tensile strength				Compressive strength			
	3 d.	1 w.	4 w.	Combined	3 d.	1 w.	4 w.	Combined
19 Jap. Portland cements	21.7–33.0	23.8–34.9	30.1–39.7	37.5–44.7	183–444	235–563	310–673	340–727
Average	26.7	29.7	34.3	42.0	311	444	551	595
Velo cement	39.1	42.6	44.8	54.3	557	613	688	785
Special cement	31.6	33.6	36.3	45.8	514	553	638	705
Super-cement	22.5	28.6	33.4	41.1	244	386	486	499
Blast-furnace cement	27.1	33.9	41.8	44.5	310	450	665	680
Soliditit	17.6	24.3	31.7	36.8	173	277	436	506

S.K.

Action of acid on cement mortar. SHOICHIRO NAGAI. *Jour. Jap. Ceram. Assn.*, **36** [428], 382–94 (1928).—The action of sulphuric and hydrochloric acids on 1:3 mortars of a Portland cement (Iwaki), a blast-furnace cement (Yawata), and a Soliditit (Tokio) has been studied. The effect of immersing test pieces in 0.3*N* H_2SO_4 after 24 hrs. (*A*) or 28 days (*B*) from molding on their tensile strength is shown in Table I.

TABLE I. TENSILE STRENGTH OF 1:3 MORTARS CURED IN WATER OR 0.3 N H_2SO_4
(Kg./sq. cm.)

Age in weeks	Blast-furnace cement			Soliditit			Portland cement		
	Water	Acid		Water	Acid		Water	Acid	
		A	B		A	B		A	B
1	27.6	26.8		26.5	24.6		25.0	25.1	
2	30.3	30.6		27.4	28.5		28.6	29.3	
4	33.3	29.8		28.7	24.9		32.1	24.7	
8	36.2	27.3	38.3	29.0	22.9	26.5	33.1	21.7	30.6
13	38.0	24.1	32.0	30.1	17.5	20.8	34.3	16.2	24.8
19	39.1	17.7	25.9	31.7	11.9	14.6	35.6	10.1	18.3
26	40.0	8.8	17.4	32.6	4.3	6.1	36.8	4.4	8.5

The action of 0.1N H_2SO_4 is comparatively strong. HCl acts more severely. S.K.

Modulus of rupture of cement mortars. II. SHOICHIRO NAGAI. *Jour. Soc. Chem. Ind.* [Japan], **31** [11], 1153–58 (1928).—The modulus of rupture of cement mortars was tested on four Japanese Portland cements and an English rapid-hardening Portland cement (ferro-concrete), using Japanese, German, and American standard sands. The main results may be summarized as follows: (1) tensile strength, modulus of rupture, and compressive strength of 1:3 mortar of each cement were nearly the same for three standard sands, if compared at the same hardening age. The coefficient of modulus of rupture to tensile strength was 2.05 for every standard sand mortar. Thus, the Japanese new standard sand is nearly equal to the German and American sands. (2) The form of test piece was changed but the modulus of rupture was practically equal in every age for these two molds. S.K.

Early strength of cement. II. SHOICHIRO NAGAI. *Jour. Jap. Ceram. Assn.*, **36** [425], 193–207 (1928).—The early strengths of an alumina cement (Lumnite), a blast-furnace cement made by the Steel Works of the Imperial Government, and two domestic early high strength Portland cements have been compared (Tables I to IV).

TABLE I. TENSILE STRENGTH OF 1:3 MORTARS
(Kg./sq. cm. (24 hrs. in moist air and 1 to 6 days in water))

Age	Hours			Days				
	6	12	18	1	2	3	5	7
Lumnite	8.7	24.1	26.9	28.1	29.0	28.0	27.6	29.0
Portland cement (9)	1.2	8.7	15.8	23.0	30.6	34.5	36.1	38.3
Portland cement (10)	2.0	13.8	23.9	25.8	30.7	32.4	33.4	34.0
Blast-furnace cement	0.6	3.4	11.8	15.9	19.8	22.5	23.8	27.4

TABLE II. COMPRESSIVE STRENGTH OF 1:3 MORTARS
(Kg./sq. cm. (24 hrs. in moist air and 1 to 6 days in water))

Age	Hours			Days				
	6	12	18	1	2	3	5	7
Lumnite	130	429	488	537	566	576	600	611
Portland cement (9)	16.0	85.5	153	233	366	469	548	581
Portland cement (10)	28.0	125	198	270	412	502	576	594
Blast-furnace cement	7.0	25.0	72.5	148	225	267	315	389

TABLE III. TENSILE STRENGTH OF 1:3 MORTARS
(Kg./sq. cm.)

	Days						
	1	2	3	5	7	14	28
Portland cement (9) aged in moist air	23.0	27.2	29.6	31.5	32.6	34.6	35.8
Portland cement after 1 day, aged in water		30.6	34.5	36.1	38.3	39.5	40.6
Portland cement (10) aged in moist air	25.8	28.6	29.8	31.3	31.6	32.2	32.2
Portland cement after 1 day aged in water		30.7	32.4	33.4	34.0	35.2	37.2

TABLE IV. COMPRESSIVE STRENGTH OF 1:3 MORTARS
(Kg./sq. cm.)

	Days						
	1	2	3	5	7	14	28
Portland cement (9) aged in moist air	233	397	458	512	528	557	577
Portland cement after 1 day aged in water		366	469	548	581	627	677
Portland cement (10) aged in moist air	270	404	445	504	516	547	569
Portland cement after 1 day aged in water		412	502	576	594	629	674

Various ratios of the strengths are discussed. S.K.

Early strength of cement. III. SHOICHIRO NAGAI. *Jour. Jap. Ceram. Assn.*, **36** [431], 537–45 (1928).—N. gives results obtained in experiments on the early strengths of Velo cement, special cement, super-cement, and two Japanese Portland cements of high silica type.

TABLE I. TENSILE STRENGTH OF 1:3 MORTAR
(Kg./sq. cm.)

	6 hr.	12 hr.	18 hr.	1 d.	2 d.	3 d.	5 d.	7 d.	28 d.	Combined 28 d.
Velo cement	1.54	14.9	24.9	29.1	37.1	39.1	40.7	42.6	44.8	54.3
Special cement	2.83	17.2	22.5	24.8	30.7	31.6	32.1	33.6	36.3	45.8
Super-cement	2.48	7.00	11.6	13.7	20.7	22.5	26.2	28.6	33.4	41.1
Portland cement	1.68	10.0	15.1	18.4	21.8	22.7	26.8	29.5	33.2	41.8
Portland cement	1.43	6.75	12.6	17.8	24.6	27.0	28.8	29.7	34.5	41.5

TABLE II. COMPRESSIVE STRENGTH OF 1:3 MORTAR
(Kg./sq. cm.)

	6 hr.	12 hr.	18 hr.	1 d.	2 d.	3 d.	7 d.	28 d.	Combined 28 d.
Velo cement	11.5	117	204	276	444	557	613	688	785
Special cement	24.0	182	286	352	475	514	553	638	705
Super-cement	17.5	46.5	82	118	190	244	386	486	499
Portland cement	21.5	83.0	124	156	223	293	437	592	620
Portland cement	18.0	52.0	94	123	202	280	481	626	663

S.K.

Early strength of cement. IV. SHOICHIRO NAGAI. *Jour. Jap. Ceram. Assn.*, **36** [432], 577–87 (1928).—This article contains chemical analyses of the cements used in the comparison tests of the early strength and described in the previous report, effect of fineness upon the early strength, and lowering of early strength by aging. (1) *Chemical Composition of the Cements.* (2) *Effect of Fineness.* Two Portland cements were sifted with a No. 300 sieve (about 13,960 meshes/sq. cm.) and the strengths of the coarser part, the original sample, and the finer part, have been compared (Tables I and II). The sifting caused no material change in their composition.

TABLE I. TENSILE STRENGTH OF 1:3 MORTAR
(Kg./sq. cm.)

	Cement	Days 1	2	3	5	7	28
(4)	Coarser part	10.7	13.8	16.4	20.5	23.1	23.8
	Original sample	23.3	23.9	25.4	27.9	29.0	30.9
	Finer part	25.4	26.2	28.6	29.8	32.2	36.2
(9)	Coarser part	11.0	18.5	23.1	25.5	29.8	34.1
	Original sample	23.0	30.6	34.5	36.1	38.3	40.6
	Finer part	26.2	34.0	38.7	39.0	41.8	43.4

TABLE II. COMPRESSIVE STRENGTH OF 1:3 MORTAR
(Kg./sq. cm.)

	Cement	Days 1	2	3	5	7	28
(4)	Coarser part	64.5	116	159	221	268	462
	Original sample	160	238	299	374	412	522
	Finer part	215	311	426	534	584	742
(9)	Coarser part	105	185	269	354	407	583
	Original sample	233	366	469	548	581	677
	Finer part	333	512	666	739	790	894

(3) *Effect of Aging.* Loss in strength due to aging has been determined by keeping a sample of cement (4) in a closed vessel connected with a source of carbonic dioxide saturated with moisture for two weeks (Table III).

TABLE III. STRENGTH OF 1:3 MORTAR WITH THE AGED CEMENT
(Kg./sq. cm.)

		Days 1	2	3	5	7	28
Tensile strength	Unaged	23.3	23.9	25.4	27.9	29.0	30.9
	Aged	3.9	5.5	8.8	16.2	21.2	26.2
Compressive strength	Unaged	160	238	299	374	412	522
	Aged	19.0	35.0	81.0	165	236	367

S.K.

Future of index of activity of Japanese cement. TAKESHI SHOJI. *Jour. Soc. Chem. Ind.* [Japan], **32** [1], 82–84 (1929).—Chemical composition of Japanese Portland cements is silica 20 to 24%, alumina 4 to 8%, ferric oxide 2 to 5%, lime 62 to 66%, magnesia 1 to 3%, and hydraulic modulus 1.85 to 2.20. Most Japanese Portland cements are siliceous and their indices of activity (SiO_2/Al_2O_3) are 4.0 or higher. Their monthly production amounts to 1,100,000 barrels, *i.e.*, more than half of the total. Table I shows the increasing tendency of the indices in these years.

TABLE I. AVERAGE ANNUAL CHEMICAL COMPOSITION OF JAPANESE PORTLAND CEMENTS (BY SOZO KANO, ONODA CEMENT MFG. CO.)

	1913	1915	1917	1919	1920	1922	1925	1926	1927
No. of plant	20	11	20	22	21	28	28	26	20
Ignition loss	2.88	3.31	3.15	2.35	2.23	3.22	2.00	2.23	1.40
Silica	22.54	21.97	21.72	22.94	22.75	22.26	22.39	22.38	22.58
Alumina	7.30	6.74	6.76	6.35	6.47	6.40	6.07	5.54	4.98
Ferric oxide	3.09	2.94	3.10	2.98	3.02	3.19	3.41	3.27	3.12
Lime	60.81	61.51	61.29	61.42	60.97	61.14	62.53	63.53	64.82
Magnesia	1.16	1.16	1.14	1.23	1.30	1.39	1.30	1.22	1.30
Insoluble residue		0.47	0.71	0.49	0.61	0.48	0.40	0.33	0.22
Hydraulic modulus	1.85	1.95	1.94	1.90	1.93	1.92	1.96	2.03	2.11
Lime factor	2.35	2.46	2.48	2.38	2.34	2.42	2.49	2.56	2.62
Silica modulus	2.21	2.27	2.22	2.46	2.42	2.32	2.36	2.54	2.79
Index of activity	3.08	3.27	3.21	3.77	3.53	3.49	3.65	4.05	4.53
Iron modulus	2.36	2.29	2.18	2.12	2.14	2.01	1.78	1.69	1.60

Discussions are given on the low silica ferruginous cements and Kuehl's patent. Conclusions: (1) The majority of Japanese cements will probably remain rich in silica and lime. The increasing tendency of the indices, however, will probably cease, because cements which contain 23% of silica and 5% or less of alumina and have indices of activity near 5.0 may be considered as their limit. (2) Some of the plants manufacturing cements with the intermediate indices, *e.g.*, 3.5, may continue the manu-

facture of similar products from the relations of equipments and raw materials, while some may undertake the manufacture of ferruginous low silica cements. S.K.

Moduli and indices relating to main hydraulic components of Portland cements. II. SHOICHIRO NAGAI. *Jour. Soc. Chem. Ind.* [Japan], **32** [3], 243–49 (1929).—Continuing the previous study, N. has proposed some new moduli and indices relating to main hydraulic components of cements and has calculated their values for many Japanese and foreign Portland cements given in the first paper to compare them with the strengths of 1:3 mortars. Some of these newly proposed moduli and indices are: lime silica ratio or lime silica combining ratio $= \frac{CaO - (1.65Al_2O_3 + 0.70Fe_2O_3 + 0.70SO_3 + \text{Free CaO})}{SiO_2 - 0.80 \times \text{insol. residue}}$, lime silica molar ratio $m = 1.07 \times 1 = 1.07 \times \frac{CaO - (1.65Al_2O_3 + 0.70Fe_2O_3 + 0.70SO_3 + \text{free CaO})}{SiO_2 - 0.80 \times \text{insol. residue}}$; molar ratio of tricalcium silicate to dicalcium silicate $= \frac{\text{molar (\%) of } 3CaO{\cdot}SiO_2}{\text{molar (\%) of } 2CaO{\cdot}SiO_2} = \frac{m - 2.00}{3.00 - m}$. The silicate lime and calcium silicate ratios were reported by N. in "Relation between Composition of Cement and Strength of Mortar on Combined Hardening." Eight means of recent Japanese Portland cements and five early high strength Portland cements are plotted on a diagram of ternary system CaO–SiO_2–Al_2O_3, and merits and demerits of many cements of low silica and high silica types of Japanese and foreign Portland cements are discussed. Three components CaO, SiO_2, and Al_2O_3 were calculated as follows: (1) CaO = total CaO − (0.70SO_3 + free CaO); (2) SiO_2 = total SiO_2 − 0.80 × insol. residue; (3) Al_2O_3 = Al_2O_3 + Fe_2O_3. S.K.

Distribution of particles of cements. KOZO FUJII. *Jour. Jap. Ceram. Assn.*, **36** [422], 46–57 (1928).—Fineness of five cements was determined successively by means of sieves, an air analyzer, and an elutriation apparatus with ethyl alcohol. Generally speaking, per cent weight of each fraction increased with decrease in their size. The weight-size curves have a minimum at a diameter of 4 to 6μ, a maximum at 8 to 10μ (10 to 14μ in a cement) and at 0 to 2μ or 2 to 4μ. Then the total surface area of 100g. of each cement is given. Chemical analyses of the cements and their fractions consisting of particles smaller than 18μ in diameter are compared (Table I).

TABLE I. CHEMICAL ANALYSES

Cement	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Ignition loss	(*a*)	(*b*)	(*c*)
II	21.10	6.91	2.29	63.90	1.03	1.53	3.01	2.11	3.05	2.29
II(fines)	20.42	6.21	2.17	61.60	0.91	1.85	6.50	2.14	3.29	2.44

(*a*) = hydraulic modulus, (*b*) = SiO_2/Al_2O_3, and (*c*) = SiO_2/R_2O_3. Discussions are given on the R. Lorenz's settling method followed to Wiegner Gessner's principle. S.K.

Graphical method of calculating cement raw mixture. KOZO FUJII. *Jour. Jap. Ceram. Assn.*, **36** [428], 369–81 (1928).—An article dealing with graphical and mathematical methods of proportioning cement raw mixtures. Conclusions: (1) When four raw materials, an hydraulic modulus, a silica modulus, and an iron modulus are given, approximate proportion of the raw materials can readily be obtained by graphical method. (2) The result must be checked, however, by a mathematical method if accurate proportion is required. (3) The graphical method shows at once the adaptability of a given raw material. S.K.

Recent progress in the cement industry. KOZO FUJII. *Jour. Soc. Chem. Ind.* [Japan], **31** [7], 660–69 (1928).—Descriptions and discussions are given on the develop-

ment of high-grade cements, classification of cements and progress in the art of cement manufacture. *I. Development of High-Grade Cements:* "High grade cement" or "special cement" is rather colloquial; they are substantially early high strength or rapid hardening cements. *II. Types of High-Grade Cements:* High-grade cements may be classified into two groups of cements: (1) Portland cement type and (2) aluminous or fused cement. The former is manufactured by sintering raw mixture at high temperatures, while the latter melts without sintering at comparatively low temperatures. Lime-alumina cement, manufactured in Belgium, is an intermediate product, melting at 1550° C. (Table I).

TABLE I. CHEMICAL COMPOSITION OF CEMENTS

	Portland	Kuehl	Lime-alumina	Aluminous
SiO_2	19–27	14–18	15.5	10–12
Al_2O_3	4–10	6–10	31	40–50
Fe_2O_3	2–4	5–10		10–20
CaO	58–67	60–65	52	35–40

Chief constituents of aluminous cement are $3CaO{\cdot}5Al_2O_3$ and $CaO{\cdot}Al_2O_3$. That those of Portland cement are $3CaO{\cdot}SiO_2$, β-$2CaO{\cdot}SiO_2$ and $3CaO{\cdot}Al_2O_3$ is still undecided. High-grade cement may further be subdivided into two kinds of high silica type, *e.g.*, Velo cement (Denmark), and high alumina type, *e.g.*, ferro concrete (England). Kuehl cement (Germany) is more aluminous. Another class contains accelerator. (1) Cement of high silica type: high lime cements show early high strength but are slow in increase of tensile strength, so the cements of high silica type were developed by increasing SiO_2:R_2O_3 ratio of the high lime cements; very careful proportioning and extra-fine grinding of raw materials as well as clinker are required for their manufacture; most of Japanese cements belong to this type. (2) Cements of high alumina type: usually single clay is used; they are apt to change into quick-setting cements and are usually weaker than those of the preceding type. (3) Kuehl cement: sinters at low temperature. Table II shows an instance where a rotary kiln of Kuehl cement was fed with a raw mixture of Portland cement for several hours from shortage of the raw materials. A Wanner pyrometer was used.

TABLE II. TEMPERATURES IN A ROTARY KILN IN °C

	Flame	Clinker	Clinker at lower end of kiln
(1) Kuehl cement	1420–1565	1300–1370	1240–1280
(2) Portland cement	1600–1610	1500–1550	1405–1420
(3) Kuehl cement		1350	1220–1240

(4) Cement with accelerator: accelerators are usually alkalis or sulphates; examples of these types are the Swedish cement (Skanska-Schneider process) and German Novo cement (Hartner process). Table II shows the strengths of Asano Portland cement with or without Schneider's accelerator or "ASB," an accelerator prepared by F.

TABLE III. STRENGTH OF 1:3 MORTAR
(Kg./sq. cm.)

	(D) Compressive strength Schneider's process		(Z) Tensile strength "ASB"	
Age in days	Without accelerator	With accelerator	Without accelerator	With accelerator
1	D 80(Z8)	D230(Z24)		
2	130(21)	290(28)		
3	210(23)	340(34)		
7	360(33)	430(34)	D572(Z38.1)	D642(Z44.3)
28	470(36)	580(40)	718(39.7)	790(55.2)
Sand	German standard sand		Japanese standard sand	
Date of test	May, 1926		Jan., 1928	

Portland cements hardening rapidly, gradually, and slowly, can be made of same materials by varying their proportion. S.K.

Action of water on tricalcium silicate and β-dicalcium silicate. T. THORVALDSON AND V. A. VIGFUSSON. *Trans. Roy. Soc. Can.*, **22** [3], III, 423–31 (1928).—The ratio of hydrolysis of tricalcium silicate and β-dicalcium silicate was studied to determine the chemical composition of the products formed. The silicates were prepared from marble and flint; after purification they were ground to pass a 200-mesh sieve and then treated with water in steel tubes until no evidence of unhydrolyzed particles could be obtained. Checks were made using gold tubes in place of the steel tubes. Tricalcium silicate hydrolyzed much more rapidly than the dicalcium silicate, and the rate of the latter after falling off increases again very rapidly. There was no indication of the existence of a stable hydrated dicalcium silicate. From comparisons of the lime-silica ratio the product of hydrolysis highest in lime which can exist in equilibrium with a solution of $Ca(OH)_2$ below saturation has approximately the composition $3CaO \cdot 2SiO_2$. An inflection of the curve of hydrolysis at a point where the lime–silica ratio is about 1:1 indicates the formation of a hydrated monocalcium silicate. The products of hydrolysis of the 2 silicates examined were identical. (*C.A.*)

Storage of cement. VIKTOR BAEHRNER. *Zement*, **17** [43], 1556–59 (1928); *Rock Prod.*, **32** [14], 94 (1929).—The storage of cement in sheds or silos affects different kinds of cements differently and affects each kind of cement differently in respect to its age. A cement may be stored twice as long in a good storage as in a cement shed without reduction of strength, whereas it may be stored for years in silos. F.P.H.

Historical review of iron-ore cement. C. PRUESSING. *Zement*, **17** [41], 1496–1500 (1928); *Rock Prod.*, **32** [13], 82 (1929).—The Portland cement plant at Hemmoor obtained (in 1903) a license to manufacture special cement for resisting the salts in sea water, mine waters, etc. Sulphuric acid and its products have met with a demand from chemical factories and other establishments handling acids and salts, for they are handled just like every first-class Portland cement. Though its initial strengths cannot be raised sufficiently to guarantee for it the strength of high-grade cements, it reaches this strength, however, in nearly every test. In comparing iron ore cement with high-grade cement, test samples of each mixed in 1:5 proportion with standard sand were prepared, stored in one case in sea water, and in another in supply water; after 7 months of storage the tensile strengths were as follows:

	Tensile strengths	
Storage 7 months	Supply water kg/cm.² (lbs./in.²)	Sea water kg/cm.² (lbs./in.²)
High-grade Portland cement	17.0 (24.18)	12.7 (180.6)
Ore cement	18.5 (263.1)	20.5 (291.6)
High-grade Portland cement	16.2 (230.4)	10.9 (155.0)
Ore cement	17.4 (247.5)	22.2 (315.8)

F.P.H.

Recent cement research. NACKEN. *Zement*, **17** [33], 1231–37 (1928); *Rock Prod.*, **32** [13], 82 (1929).—N. delivered a report on a recent research in the chemistry of cements at the 51st general meeting of the Society of German Portland Cement Mfrs. at Berlin in March, 1928, dealing with (1) the examination of microscope slides of the kinds of crystals in the technical Portland cement clinker by A. Guttmann and F. Gille, which showed two crystallized constituents, the alit and belit, the first said to contain considerable alumina and the second said to be a α or β modification of the dicalcium silicate; (2) further examination of crystals by N. with water-free calcium chloride as solvent for the silicates and other combinations, heated to high temperatures, although CaF_2 is also an excellent solvent; (3) study of a number of systems of silicic acid with BaO, SrO, M_2O, FeO, and PbO with tables and diagrams concerning

various ortho- and meta-silicates giving melting temperatures and formation heat and details of crystals, and (4) discussion of the study of lime action in cement as carried out by Becker and Day at the Carnegie Institute. N. explains lime action of cement as due to water entering into cement and then into combination with CaO to form $Ca(OH)_2$, in which process a decrease in volume occurs leaving space for further water to enter repeatedly, which remains fixed and expands the cement, chipping it off. F.P.H.

Cement exhibited at the Tokio Exposition, 1928. SEIJI KONDO AND AITARO MIYAGAWA. *Jour. Jap. Ceram. Assn.*, **36** [428], 395 (1928).—A report on the tests of various cements exhibited at the Tokio Exposition held at Ueno in 1928. S.K.

Transportation of bulk cement. ANON. *Cement, Mill & Quarry*, **34** [7], 15–18 (1929).—The first handling of bulk cement by ships equipped with the Leathem D. Smith tunnel scraper system was accomplished by the steamer Sinaloa at Cleveland, Ohio, where she discharged a cargo of bulk cement into silos owned by the Great Lakes Portland Cement Co. E.P.R.

BOOK

Cement, Limes, and Plasters. EDWIN C. ECKELS. 3rd ed. John Wiley and Sons, New York. 770 pp., 269 tables; reviewed in *Rock Prod.*, **32** [12], 92 (1929).—The primary object of the first two editions of this volume was to provide a summary of the extensive literature on cementing materials. The term is used in its broadest sense and includes plasters, limes, and hydraulic cements. E., in the third edition, attempts to carry out this basic principle and discusses as well, the various phases of composition, sources of raw materials, and physical and chemical properties of the raw and finished cements. This edition, outside of the last chapter dealing with alumina cements and high-strength Portland cements, contains very little new material. With present-day methods and technique in the lime and plaster industry, considerable value could have been added to the book by bringing the portions dealing with those subjects up-to-date. The last 43 pp. of the book deal with the comparatively new alumina and accelerated cements and is a subject with which E. is familiar and his statements can be relied upon as being authoritative. In this chapter alumina cements are defined and their analysis and properties compared with Portland, natural, and slag cements. The sources of material for this type of cement and an analysis of the principal source of alumina and bauxite, are well covered. F.P.H.

PATENT

Cement compositions. A. METHERELL. Brit. 310,875, June 26, 1929. A waterproofing and glaze-forming composition for adding to the gaging water of cement mortars and concretes, comprises a mixture of metallic sulphates or other salts. The preferred mixture comprises equal volumes of aluminium, magnesium, sodium, and potassium sulphates. Various changes may be made in this mixture, *e.g.*, some of the sulphates may be omitted or replaced by the sulphates of other metals such as zinc or iron, or by other salts such as potassium or magnesium chloride or sodium silicate. Calcium chloride is not used. Examples of these modified mixtures are (*a*) 2 parts of sodium sulphate, 2 parts of zinc sulphate, 4 parts of potassium chloride and 1 part of magnesium chloride, and (*b*) equal parts of sodium silicate, aluminium sulphate, potassium chloride, and magnesium sulphate.

Enamels

Effect of soluble salts on the properties of enamels. R. R. DANIELSON. *Jour. Amer. Ceram. Soc.*, **12** [8], 538–47 (1929).—(1) Enamels, in common with other types of glasses, are more or less soluble in water, depending on their compositions. The

nature and quantity of salts dissolved from the enamel glass during milling have a very definite bearing on the suspension, workability, and other properties of the enamel, such as pitting and crawling. (2) Those enamels which produce mill liquors which are excessively alkaline have very poor floating qualities. The ratio of free alkali to boric oxide dissolved from the enamel frit is an important factor in the flotation properties of the enamel. (3) The poor floating powers of certain enamels can be corrected by the addition of suitable electrolytes. The kind and quantity of salts dissolved from the frit will determine the selection of the proper electrolyte. Enamel composition having minimum solubility for good suspension and other properties are given. (4) The value of an enamel clay cannot be determined by floating the clay in water. Tests must be made with the clay in the type of enamel with which it is to be used. (5) Any studies on the effect of aging of enamels on their working properties must give consideration to the constitution and quantity of the individual salts dissolved from the enamel frit, and to the action of carbon dioxide in neutralizing part of the free alkali.

Adhesion of white ground coat in reference to iron and enamel oxides. ANTON KONETSCHNIGG. *Emaillewaren-Ind.*, **6** [20], 159–60 (1929).—Not every glaze can be used as a ground coat especially if containing zinc oxide. During firing, oxidation will take place all over the sheet-metal surface and, if the ground coat contains no oxygen carrier, the air within the muffle will supply the necessary oxygen. The sheet metal surface will take on a loosely adhering very fine film of FeO below the glaze, evidenced by green color on transparent glazes. If, however, an oxygen carrier is present in the glaze (BaO_2, MnO_2, Mn_3O_4, Co_2O_3, Ni_2O_3, Sb_2O_3, Sb_2O_5, As_2O_3), the oxygen from here will help to oxidize the iron, the oxide film being heavier and of different composition (Fe_2O_3, Fe_3O_4). The firmness with which the ground coat will adhere is governed by the firmness with which the oxide film will adhere to the sheet, the particles of Fe_3O_4 adhering firmest. That ground coat will adhere best when it is in a position to supply sufficient oxygen uniformly all over the metal surface, and the temperature is to be carried high (about 1000°C). BaO_2, Sb_2O_3, Sb_2O_5, ZnO will give a more or less white ground coat of good adhesion. T.W.G.

Art of enameling in association with glass manufacture and ceramics. W. SELESNEFF. *Trans. Ceram. Res. Inst.* [Leningrad], No. 3 (1926).—A historical review is presented. (*Trans. Ceram. Soc.* [Eng.])

Enameling sheet steel. IV. Milling of enamel frits. WALTER SCHULZ. *Ceram. Ind.*, **13** [1], 60–63 (1929).—The milling or grinding of enamel frits is done in the milling room of the enameling plant. Formerly the open mills were used, and, in some cases, are still preferred to obtain a really glossy, very finely ground enamel, which, if ground in pebble mills, would lose some of its luster. In closed pebble mills very finely ground enamels concentrate so much heat that they easily overburn. Today, ordinary enamels are ground in pebble mills. The continuous mill is used only for the dry grinding of some cast-iron enamels, and to greatest advantage. This process is cheap and convenient for dry cast-iron enamels. The dry frit (must be thoroughly dry or else it will form lumps and will not grind) is fed automatically into the one end of the continuous mill. The powdered enamel frit is delivered at the other end of the mill to an air separator which takes the correctly ground particles to a storage bin and returns the coarse particles to the mill for regrinding. F.P.H.

Enameled sheet steel for building. ANON. *Ceram. Ind.*, **13** [1], 58 (1929); *Iron Trade Rev.*, June, 1929.—The application of porcelain enameled steel sheets for construction work is discussed. Porcelain enameled steel can be used to build portable buildings which are both attractive and practical. The enameled steel exterior of the building gives it an air of cleanliness and resembles marble. F.P.H.

BOOK

Email-Taschenbuch, 1929. 2 vols. Keramische Rundschau (Tonindustrie-Zeitung), Berlin. M. 4.75. (*C.A.*)

PATENTS

Colored opacifying pigments. CHARLES J. KINZIE. U. S. 1,719,432, July 2, 1929. The method of making composite colored opacifying pigments for vitreous enamels which comprises heating a charge composed preponderatingly of a zirconium compound, a fluxing agent and coloring material with homogeneous distribution of the coloring material through the zirconium compound and cooling the resulting mass.

Enamels. DEUTSCHE GASGLÜHLICHT-AUER-GES. Brit. 310,528, June 19, 1929. The method of making white enamel, particularly for enameling sheet or cast metal by the wet process, in which the opacifying media are highly basic compounds or salt-containing complexes of tin, zirconium, titanium, etc., usually used for the purpose, is given. The invention consists in using enamels containing little or no fluorides, the opacifying media being added during the grinding operation in the mill.

Glass

Measurement of absolute viscosity by use of concentric cylinders. I. HOWARD R. LILLIE. *Jour. Amer. Ceram. Soc.*, **12** [8], 505–15 (1929).—A method is described for the measurement of absolute viscosities of liquids, employing the torque exerted upon a stationary inner cylinder or spindle, suspended by means of a torsion member into the center of a fluid, when the cylindrical container is given a uniform angular motion. A method for calibrating the suspensions is described. The "true" viscosity of the castor oil, used as a test fluid, is found by extrapolating values of apparent viscosity, given by spindles of various lengths but equal radii, to that value corresponding to infinite length. For the oil being used, the viscosity at 20°C is given by this method as 9.67 poises. Using this as the true value, the effective length and thereby the end effect in terms of additional length may be found for any spindle in a liquid of given finite boundaries. The end correction to length so determined for a spindle of 0.5 cm. radius by 10 cm. length in the center of a liquid of boundaries 3.2 cm. radius by 13 cm. height a system similar to that used in measuring glass viscosities, was found to be 0.44 cm. See following abstract for Part II.

Viscosity measurements in glass. II. HOWARD R. LILLIE. *Jour. Amer. Ceram. Soc.*, **12** [8], 516–29 (1929).—The concentric cylinder method, described in a previous paper, has been used in the measurement of viscosities in molten glass. The apparatus and method of measurement are fully described. Comparisons are made between results obtained and those of English, Stott, and Washburn. Quite good checks are found in comparisons with English and with Stott, but results obtained in comparing with Washburn indicate a difference supposedly due to his use of a variable calibrating factor. Measurements made by the use of a falling sphere give values of viscosity 25 to 50% higher than those given by the concentric cylinders in the same glasses. This may be due to the extended extrapolation of Ladenburg's correction for finite boundaries.

Volatility of selenium and its compounds in the manufacture of glass. J. B. KRAK. *Jour. Amer. Ceram. Soc.*, **12** [8], 530–37 (1929).—The volatility of selenium in making selenium ruby glass has been studied. About 75% of the selenium added to the batch was lost by volatilization. Sodium selenite and barium selenite were stable at 950°C and are probably stable at higher temperatures. Regardless of whether selenium or the compounds studied are used, the resulting glass contains about equal amounts of selenium. Methods of preparing sodium and barium selenites are described. An outline is given of an analytical procedure by which selenium is determined in glass.

Methods and results of an investigation on the viscosity of glass. P. P. LAZAREFF.

Ceramics and Glass [U.S.S.R.], **7**, 180–86 (1928).—L. describes methods employed and tests made on the internal friction (viscosity) of glass at different temperatures to establish the dependence of the viscosity on the change in temperature. Two methods used were: (1) observation of the fall of a small platinum ball dropped into the melted glass, and (2) observation of the velocity of the fall of a weight by which the rotation of a small platinum cylinder placed inside of a platinum melting pot filled with liquid glass is caused; the weight is connected with the cylinder by a special arrangement. Data concerning the viscosity are calculated from the empirical formula proposed by Le Chatelier:

$$\lg \lg \eta/\eta_0 = A - Bt,$$

in which η is the viscosity and η_0, A and B are constants. Tables for the comparison of the data on the viscosity of different liquids and as melted glass are given. The results are considered to be very satisfactory. In conclusion, graphical representations of the data obtained by the two methods of investigation are given. W.A.

Hardening and softening of glass. P. P. LAZAREFF. *Ceramics and Glass* [U.S.S.R.], **8**, 219–23 (1928).—Based on the well-known fact that hardened glass, that is, glass heated up to 600 to 800° and then cooled quickly, displays the phenomenon of double refraction, as well as a series of other new properties, and taking into consideration that the process of tempering glass is therefore of great technical importance, L. performed tests which are very valuable from the physico-chemical viewpoint. The results of his tests are given. The description includes the following items: (1) Methods of investigation; utilization of the property of tempered glass of displaying double refraction. (2) Theory of the process of tempering; distribution of molecules and atoms. (3) General properties of glass tempered to different degrees of hardness: density, hardness, heating capacity. (4) Mechanical and chemical elaboration of tempered glass. (5) Investigation of the properties of tempered glass by means of röntgenoscopy. Photographs and diagrams illustrate the articles. W.A.

Permeability of glass for ultra-violet rays. G. ROSE. *Sprechsaal*, **62** [18], 314–15; [19], 333–35; [20], 352–55; [21], 375–77 (1929).—A dissertation giving a review of the history of Vita glass (Vita Glass Corp., England), and the results of tests on school children and zoo animals, giving an illustrated description of the apparatus for measuring permeability, giving calculations for the measurement of permeability, the determination of FeO and Fe_2O_3 in the glass, the permeability of iron-salt solution, of commercial glasses and tests, of globes for electric lights of importance to medicine. R. gives the following conclusions: (1) permeability of a glass for ultra-violet light increases with a decrease of Fe_2O_3; (2) total iron content as well as the degree of oxidation of the iron are of importance to permeability; (3) FeO is less absorbing than Fe_2O_3; (4) ultra-violet absorption of trivalent iron in solution is 100 times stronger than the absorption by bivalent iron; (5) reduction of permeability under the influence of ultra-violet light is caused by re-oxidation of bivalent iron; (6) conversion of bivalent to trivalent iron-salt in solution is hastened by the exposure to ultra-violet light; (7) by means of permeability curves it is possible to obtain pointers for the FeO, Fe_2O_3 ratio in glasses with small iron content where the methods for the determination of bivalent and trivalent iron fail. T.W.G.

Ultra-violet transmitting window glass. GEORG JAECKEL. *Glastech. Ber.*, **6** [6], 281–93 (1928).—A review is made of experiments conducted in connection with the new ultra-violet transmitting glass. The brands of this type of glass on the market were examined for their transmissivity and the results are given. An explanation is given, from a physical standpoint, which clarifies the meaning of the term "ultra-violet." The true value of ultra-violet transmitting glass will not be definitely known until after extended biological research has been conducted in connection with its use. E.J.V.

Properties and applications of Vita glass. F. E. LAMPLOUGH. *Pottery Gaz.*, **54** [625], 1120–23 (1929).—The physical aspects of Vita glass and the character of the ultra-violet rays, which are included in a wave-length range of 3000 to 3200Å units are given. As ordinary glass is practically opaque to rays below 3300 it obstructs the beneficial rays. Vita glass transmits radiation well below the wave-length 3000Å units. The permeability of the new glass to the vital rays can be shown in various ways. These rays cause sunburn and pigmentation of the skin, and the effect frequently is nearly as marked when Vita glass is used to screen the sun as without the screen. The fading of a special blue dye has been used as a criterion to measure the amount of valuable rays transmitted by the glass. The best visible demonstration is given by the use of fluorescent substances, such as uranium glass, or various dyes, which have the property of glowing in ultra-violet rays. In making the experiment, the beam from a mercury vapor lamp is filtered by a film of silver deposited on quartz or thin Vita glass, so that rays chiefly of the wave-length 3130 are isolated and produce the glow of fluorescence. The interposition of a sheet of Vita glass reduces this effect only slightly, but a sheet of ordinary glass practically extinguishes it. Transparency to ultra-violet radiation is not the only property of importance in glass of this kind. It must retain this transparency without important loss on exposure to sunlight, and it must be resistant to atmospheric attack. In addition, glass which is used for living-rooms must be as free as possible from visible defects which would distort vision. The efficiency figure of the glass depends on many factors, one at least of which cannot be determined with exactitude. These include (*a*) the relative beneficial effect of rays of equal intensity but of different wave-length; (*b*) the intensities of the different wave-lengths present in the particular incident light; and (*c*) the transmission of the glass for rays of different wave-length. These factors are discussed in detail. E.J.V.

Change in the optical transparency of certain ultra-violet transmitting glasses after exposure to X-rays and ultra-violet light. G. M. SHRUM, C. G. PATTEN, AND H. D. SMITH. *Trans. Roy. Soc. Can.*, **22** [3], 433–36 (1928).—Samples of commercial glasses said to be transparent to short-wave lengths were treated to ultra-violet and to X-ray radiation and the solarization and coloration examined. Heat treatment at 300° removed the ability to luminesce from glasses exposed to quartz Hg-arc radiation. Similar heat treatment was equally efficient with luminescence following exposure to X-ray radiation. The disappearance of the thermoluminescence was marked by the complete recovery of the glass optically to transmit all wave-lengths equally as well as when new. Coloration observed in the glasses exposed to X-ray radiation faded when the glasses were maintained for a time at 100°. The coloration and decoloration are assumed to be due to oxidation followed by reduction of certain constituents in the glass. (*C.A.*)

Cell-wire glass and ultra-violet transmitting glass. GEORG JAECKEL. *Glastech. Ber.*, **6** [6], 293–95 (1928).—Since the introduction of ultra-violet transmitting glass a competitive material consisting of a fine wire gauze impregnated with an organic substance capable of transmitting ultra-violet has been brought onto the market. Comparative tests on the two materials and their results are discussed. The various advantages and disadvantages of each are touched on. E.J.V.

Manufacture of wire glass. JOSEPH ROSSMAN. *Glass Ind.*, **10** [7], 157–62 (1929).—Nearly 200 patents have been granted relating to the manufacture of wire glass. Many problems and difficulties have been encountered in its commercial manufacture. The difference in the thermal expansion of the glass and wire has been a source of trouble. Elimination of bubbles in the final product has been difficult. The impurities on the wire and gases in the metal often cause defects. Rust spots on sheets of wire cause what is known as "moss" spots in the glass. Detailed discussions are given of the

solid process, the sandwich process, drawing the glass and embedding the wire simultaneously forming and uniting the sheets, and the Schmertz process. E.J.V.

Impact tests with glass. OTTO GRAF. *Glastech. Ber.*, **6** [10], 582–84 (1929).—Tests on the brittleness of glass by breaking opal glass bulbs with a pendulum hammer showed that glass that had been worked at 1050° or above had a greater resistance to impact than had glass worked at temperatures below 1050°. E.J.V.

Effect of cullet on rate of melting and other properties of soda-lime-silica glasses. F. W. HODKIN, H. W. HOWES, AND W. E. S. TURNER. *Glastech. Ber.*, **6** [12], 681–92 (1929).—Effect of cullet on the properties of a series of five soda-lime-silica glasses, is discussed in detail as to composition, additions of cullet, treatment, etc. The influence of cullet on the working properties, the effect of its form, and the composition of the glasses and its possible relation to the changing of the viscosity are studied. No sudden change in the working viscosity was observed, the change being continuous throughout the entire series, and glass made of 100% cullet was still workable if suitable viscosity still existed. The cullet proportions at which the machine works to the best advantage should be determined and held constant especially in machine production. A change in the cullet ratio produces a change in the working viscosity and a new regulation of the machine is necessary. The size of cullet has an important effect on the properties of glass, the finer size being better. No definite connection could be deduced from the work done on the compositions of the glasses and their relations to the change in viscosity. E.J.V.

Dependence of relative water corrodibility of glasses on chemical composition. OSCAR KNAPP. *Glastech. Ber.*, **6** [8], 447–52 (1928).—Investigations show that the water corrodibility of a glass increases with an increase in the mol percentage of soda and potash. An interesting result is obtained with soda-lime-silica glasses in which the soda is kept practically constant and the lime and silica are varied. With increasing lime content the amount of glass dissolving decreases and the amount per 1% CaO in the glass rapidly decreases. Data and results on various glass compositions are given. E.J.V.

Chemical corrodibility of glass. FRIEDRICH SPÄTE. *Glastech. Ber.*, **6** [11], 635–45 (1929).—To classify a glass according to its behavior toward water at least two methods are to be applied: (1) the standard grit method, and (2) Mylius' extraction on surface of a glass object at 100°C. The weathering test is used especially for optical glass; the flat glass test is used for window and plate glass. E.J.V.

Solubility of glasses in water. ERNST FISCHER AND WALTER TEPOHL. *Glastech. Ber.*, **6** [9], 532–39 (1928).—A discussion of various methods of classifying glasses according to their solubility in water and a new method which involves the boiling of glass of definite grain size in water and determining the amount dissolved by evaporating to dryness is presented. E.J.V.

Homogeneity of glasses. H. JEBSEN-MARWEDEL. *Glastech. Ber.*, **7** [1], 25–34 (1929).—Moisture deranges the composition of the batch. Homogeneity is not produced by the use of grains of similar weight. According to Parkin and Turner, soda must be used considerably finer, while a medium size lime grain acts satisfactorily. Homegenization of glass batches progresses best with 2 to 4% moisture. Damp sand adsorbs a part of the soda which furthers the melting. Parkin and Turner found that glass batch with 2 to 4% moisture could be most quickly melted. Uniform distribution of small additions such as decolorizers can best be brought about by premixing with a portion of the sand. Moisture exerts a protective effect against unmixing. Dusting of the mix in the pot results in deposition in the gas chamber of soda. Test methods for control are described. E.J.V.

Fused silica in chemical plant construction. W. W. WINSHIP. *Can. Chem. Met.*,

13 [7], 185–87 (1929).—Fused silica ware or vitreous silica, "Vitreosil," combines indifference to continued exposure up to 1000 to 1100°C, immunity to extremes of temperature changes, and incorrodibility from mineral acids and halogen compounds except phosphoric acid and hydrofluoric acids. Cascade concentrators, niter pot pipes and Glover tower lips and gutters are some of the chamber plant details for which fused silica ware is especially suitable. Fused silica scrap is used as a catalyst support in the manufacture of miscellaneous refractories and cements (where a low-expansion material is required), for artificial teeth mixtures, in foundry technology, and for the production of new ceramic products. In the electrical engineering field Vitreosil has valued characteristics, possessing a high electrical resistivity even at elevated temperatures, while its impermeability, low expansion, and indifference to chemical action are distinctly advantageous. Resistance heaters may be made of Vitreosil tubing with resistance wire either inside or outside the silica sheath, while the National Physical Laboratory in its report for 1928 mentions resistance units consisting of graphite or carbon pellets contained in a refractory tube such as fused silica. Fused quartz is apparently the only material available at the moment which transmits infra-red, the visible spectrum and ultra-violet light down to perhaps 2000Å effectively, and can be readily fabricated into various shapes. The quartz mercury vapor lamp is a familiar appliance in this field, while its various accessories such as prisms, lenses, and applicators are advantageously made from the same material. E.J.V.

Physics of glass. GEORGE GEHLHOFF. *Glastech. Ber.*, **6** [8], 410–47 (1928).—Glass in the technical sense is an isotropic solid, generally transparent and colorless, resulting from a fusion of sand, soda, and lime, about the composition 60 to 70% SiO_2, 10 to 20% Na_2O, 5 to 15% CaO. Its widespread practical and technical use is due to the following properties: (1) mechanical stability, (2) transparency, (3) chemical resistivity to attack by liquids and vapors, and (4) relatively easy formability in the fluid state at high temperatures. The economic applications of glass are manifold. A general view of the physics of glass is given. After briefly taking up the topics of glass constituents and glass raw materials the general properties of glasses are discussed. These include the constitution, the three states of glass, vitrification and devitrification, viscosity, specific differences of action, strain, annealing, cooling, rapid cooling, viscosity in the brittle state, resistivity of glasses, seeming devitrification of attacked surfaces, and some special physical properties of glasses. Mechanical properties discussed, include brittleness, density, thermal requirements such as thermal resistivity, specific heat, heat conductivity, and expansion coefficient. Refraction and dispersion, transparency, colored glasses, decolorization, infra-red permeability, ultra-violet transmission, and opaque glasses are taken up under optical properties. Electrical properties include conductivity, electrical analysis, the glassy skin effect, dielectric losses, dielectric constants, and resistance to puncture. The discussion under each of these headings includes data obtained in experimental work done on glasses over an extended period of time. In the last decade, the field of glass has been worked with great success, so that today we have a far-reaching insight into the constitution and properties of glasses and are in a position to calculate in an approximate way every property of a glass from the composition. While this method is as yet empirical it has already borne fruit in all branches of glass technology. We have learned to know new properties of glasses and their technical utilization, and have obtained worthwhile bases for the working-up of glasses and technical control in the production and working process. Today we are able to control the field of glass production in a way that a decade ago was considered impossible. It is quite certain that this hitherto insufficiently evaluated material was discovered to be of increasing importance through physical research and its results. E.J.V.

Annealing of glass. E. A. Coad-Pryor. *Glastech. Ber.*, **6** [12], 692–700 (1929).—The temperature of the bottles leaving the machine varies greatly with different machines and with types and weights of bottles. During transfer from the machine to the leer, glass loses heat rapidly, and the importance of quick transfer from machine to leer must be recognized. A delay of 30 sec. wastes heat equivalent to 10 lbs. of coal for every ton of glass annealed. Many annealing troubles have been relieved by shortening the time of transfer. One form of an ideal leer would be a simple tunnel, well insulated, with no surrounding flues, and of the minimum superficial area practicable in order to reduce heat losses over the first 15 ft. In this section of the leer, running it at a reasonable speed of about 12 in./min., the bottles would be well annealed and ready for rapid cooling. Where conditions allow a slower rate of cooling the insulation might be diminished after the first 10 ft., but if space is not of primary importance 15 ft. is recommended as giving an ample margin of safety. The insulation suggested is 14 in. of good quality insulating brick. Following the heavily insulated zone, the next 6 ft. of the leer can be built of fire brick with a 2-in. layer of insulation, or from sheet metal with $4^1/_2$ in. of insulation around it. Hereafter no insulation is required. Avoidance of drafts in the leer is important in annealing, especially at the hot end of the leer. A pneumatically operated door, opened by the pressure of the fork on a bar in front of the leer is advised. The essential factor at the hot end of the leer is the temperature of the conveyer at the moment the glass is placed upon it. The total annealing time depends on the uniformity with which the cooling can be carried on. The cooling air should flow at right angles to the movement of the bottles. E.J.V.

Gases and water contained in glasses. Alfred Becker and Hermann Salmang. *Glastech. Ber.*, **6** [11], 625–34 (1929).—The presence of gases in glass can be readily explained. They are due to the dissociation of the residual undecomposed batch materials in glass, chiefly carbonates and sulphates. It is more difficult to explain the origin and the state of combination of water which occurs in glass in relatively large amounts (0.02 to 0.08%), although glass has passed through temperatures which may exceed 1400°C. Turner proved that batches with varying amounts of moisture yielded glasses having varying working properties. In order to obtain an insight as to the ways in which water is combined in glass, a soda-lime glass was melted from batches containing different amounts of moisture, until only small blisters were left in the glass. These were examined in a vacuum apparatus. Moisture was increased to 10%, but water could not be detected. This result is contrary to that obtained in practice and by Turner's experiments. But this lack of agreement is only apparent, because in glass furnaces and in Turner's experiments, which were carried out on a large scale, conditions were different from those in the laboratory. When melting glass in pots or tanks the outer layers of batch piles are already red hot when the water of the center parts is not completely evaporated. This water must pass through the outside layer and may react with hot batch. This reaction is favored since the outside layer is of a basic character, and because at high temperatures steam has stronger acidic properties than silica. It is possible to decompose glass in an autoclave by means of steam. In the laboratory experiments, however, the moisture of the batch is evaporated almost everywhere at the same time, and the reaction between water and molten glass does not occur. On investigation of this problem on glass from a small tank, made from batches with intentionally varying water content, it was found that no variation in working properties could be observed. In the vacuum apparatus, glasses yielded irregular results. In general, however, the moisture content of the glass made from batches containing most water had the highest water contents. The influence of the steam content of the furnace atmosphere is not known. The development of gases during the melting of glass does not result only from the decomposition of carbonates and sulphates. Labora-

tory experiments show that a strongly reducing atmosphere increases the formation of seeds in saltcake glass, and under these conditions it becomes impossible to properly refine a glass. This must be attributed to reduction of the sulphate in the glass by the carbon monoxide in the furnace gas. In addition the inclusion of air by the pores of the pot must be mentioned. The small amount of air occupying these pores escapes into the glass and forms bubbles round the sides of the pots causing a series of seeds to pass upward from the pot bottom. This is supported by the common experience of the glasshouse that seedy glass often occurs in old pots. E.J.V.

Soda-zinc glasses. KITSUZO FUWA, SUKEHARU SAKAI, MASABUMI SATO, AND FUJIO SUZUKI. *Jour. Jap. Ceram. Assn.*, **36** [424], 135–53; [426], 243–64 (1928).—The results obtained from experiments on the influence of chemical composition of glasses 0.5–2 Na_2O 0–6 $ZnO{\cdot}6SiO_2$ upon their melting, weathering, devitrification, workability, effect of reheating, coefficient of expansion, elongation, thermal endurance, and resistance to chemicals are discussed. (1) *Melting Experiments:* Glasses within a hexagon 1.0 Na_2O, 0.25 ZnO–0.75 Na_2O, 1.75 ZnO–1.0 Na_2O, 4.0 ZnO–1.75 Na_2O, 5.0 ZnO–2.0 Na_2O, 2.5 ZnO–1.75 Na_2O, 0.75 ZnO were workable, being free from devitrification, weathering, and difficulty of melting. (2) *Effect of Reheating the Glasses:* Results are given with tables and diagrams. (3) *Coefficient of Expansion:* The thermal expansion of the glasses has been measured and the constants given by Winkelmann-Schott and English-Turner are discussed. The former agree better with facts than the latter except $(2\text{-}x)Na_2O{\cdot}xZnO{\cdot}6SiO_2$. The following constants are claimed to be best:

Oxide	Winkelmann and Schott	English and Turner	New constants
Silica	0.8×10^{-7}	0.15×10^{-7}	0.722×10^{-7}
Soda	10.0×10^{-7}	12.96×10^{-7}	10.65×10^{-7}
Alumina	5.0×10^{-7}	0.52×10^{-7}	0.45×10^{-7}
Zinc	1.8×10^{-7}	2.1×10^{-7}	1.74×10^{-7}

(4) *Pull Test:* The rate of elongation of $yNa_2O{\cdot}xZnO{\cdot}6SiO_2$ increases with increase of x. The increase in the rate tends to be weakened with increase of y. (5) *Thermal Endurance:* The lowest temperatures at which tubes of a fixed size have been cracked when they were dropped in cold water have been measured. Generally speaking, the zinc glasses endure better than lime glasses and the endurance is not much influenced by the variation in x as long as y is small, while it is reduced by the increase in x, when y becomes large. The formula of Winkelmann-Schott was not valid for the specimens. (6) *Resistance to Chemicals.* (*a*) *Water:* The glasses are very resistant to water as long as x is not small. The resistance is not much influenced by the proportion of x and y. Glasses $0.75Na_2O1.0\text{–}2.0ZnO{\cdot}6SiO_2$ proved to be most resistant. (*b*) *HCl:* The resistance to HCl is much influenced by the variation in x and y; $1.0Na_2O{\cdot}1.25$ $ZnO{\cdot}6SiO_2$ was most insoluble. (*c*) *NaOH:* The glasses are not resistant to NaOH solution. The variation in the resistance is small except the glasses with small y or with certain ranges of x. (*d*) *Na_2CO_3:* The solubility in sodium carbonate solution is not small but not so large as in caustic soda. S.K.

Frosting glass by etching. MINEICHI MASUDA. *Jour. Jap. Ceram. Assn.*, **36** [425], 183–92 (1928).—Experimental work is described which leads to the conclusion that among various theories of frosting phenomenon only the protection theory is right. (1) *Samples:* Soda-lead and soda-lime bulb glasses were etched with a solution composed of ammonium fluoride 12, hydrofluoric acid 8, and water 12. The frosted surfaces showed no double refraction. (2) *Refractive Index:* No difference in refractive index was observable between the crystalline and unetched parts. (3) *X-Ray Analysis:* The powder of the frosted glasses gave no pattern in X-ray spectra. (4) *White film produced on the frosted surface of a transparent quartz glass.* Grains constituting a white film on the frosted surface of a transparent quartz glass did not act on polarized lights

and had a same n_D of 1.370. $(NH_4)_2SiF_6$ prepared for the sake of comparison had the same index, *i.e.*, 1.370. The white film and the ammonium silico-fluoride gave X-ray spectra. S.K.

Coating and welding of glass. SANGORO MURAKAMI. *Jour. Jap. Ceram. Assn.*, **36** [427], 303–11 (1928).—M. gives results obtained in experiments on coating and welding of glasses. Results: (1) In coating a glass on another, that with larger coefficient of expansion is cracked. In tubes, the cracks have net-like shapes on the inside and lengthwise straight lines on the outside. Difference in coefficient of expansion should be under 60×10^{-8} for safe coating. That with the larger coefficient shall be used on outside. (2) In welding, such glasses are taken that one gives an elongation under 1.5 times of the other in pull test. (3) A flexible tube with spiral cracks can be obtained by coating a glass on both sides of another with smaller coefficient of expansion or by coating thickly a glass on another with smaller coefficient of expansion. S.K.

Devitrification of glass. XII. Devitrification of glasses containing B_2O_3. KOZO TABATA. *Jour. Soc. Chem. Ind.* [Japan], **31** [4], 372–73 (1928).—Experiments have been made of devitrification of glasses composed of R_2O 0.8–2.0 RO 0.25–0.5 B_2O_3 3.25–10.5 SiO_2. Summary: (1) The crystals produced by appropriate heat treatment are silica. (2) Boron compounds present in the glasses are RBO_2. (3) The power of reaction of Na_2O toward B_2O_3 may exceed that of K_2O. S.K.

Miter cutting machine. ANON. *Nat. Glass Budget*, **45** [10], 17 (1929).—A new machine for miter cutting glass ranging in size from 6 in. to 104 in. sq. with equal ease and efficiency is now being introduced into the trade by Carruthers & Large (San Francisco). The machine for cutting the miters is easily adjusted to any height of table and to any unevenness of the floor. A balance-weight control on the universal head or cutter and the speed of the carriage determines the extent of the cut. With this flexible contact the cut can be made with one operation. E.P.R.

Roirant vacuum bottle-blowing machine. ANON. *Nat. Glass Budget*, **45** [9], 3 (1929).—The Roirant bottle-blowing machine, Type B, built in France, is attracting favorable comment. It operates automatically by vacuum and is equipped with only one set of molds. The suction or blank mold is introduced directly into the tank or furnace and the metal is drawn into the mold by vacuum. The blank is transferred to the blow mold and blown. While one bottle is being blown, metal for another is being gathered. The machine operates without either a revolving pot or feeder. The mechanical movements of the machine are so controlled that the obtaining of molten glass, time of sojourn in the molds, and cooling of the molds are variable in a wide range. These features permit the machine to function with glass of varying temperatures and compositions. Owing to the fact that the Roirant machine is narrow in construction any desired number can be worked on a tank equal to its melting capacity. Because it is connected directly to the tank and works by suction and without intermediate equipment between it and the tank a big advantage is afforded. E.P.R.

Glass furnace fuel consumption. F. G. SCHWALBE. *Nat. Glass Budget*, **45** [7], 7 (1929).—Glass manufacturers are seeking the aid of trained men when work is to be done on the melting furnace. Consulting engineers are of great assistance to the glass manufacturer when building new equipment, or making a decision as to what kind and whose equipment to install. Fuel is a big cost item. A figure representing fuel consumption per ton of glass, should be accompanied by the following: (1) fuel and its heat value; (2) size of furnace; (3) type and composition of glass to be melted; (4) type of furnace, regenerative or recuperative; (5) whether ventilation air or water boxes are used on the flux side walls; (6) whether insulation is used; (7) length of time the furnace has been in operation; (8) the seasons of the year. E.P.R.

Laminated glass stands police test. ANON. *Nat. Glass Budget*, **45** [8], 14 (1929).—Tests made recently of the laminated glass or bullet-proof glass that is to be used in glazing bandit-chasing cars, proved successful. The laminated glass used in the tests was manufactured at the factory of the American Window Glass Co. Under five shots from a service revolver the glass cracked but did not splinter or become pierced. E.P.R.

Breakage of glass, causes of; how to study detail of structure in broken glass. FRANK W. PRESTON. *Ceram. Ind.*, **13** [1], 40–45 (1929).—One of the curious features of glass breakage is that very often the glass does not break where the tension is greatest but at some point where it is very much less than the maximum. This means that the glass, apparently homogeneous, is much stronger in some parts than others. As a rule the weak spots cannot be detected by inspection, even with microscope or polariscopes. Only an actual test to destruction will reveal them. A glass broken by impact is not necessarily any different in appearance from glass broken by simple pressure. Impact fractures originate in an area where there is an intense localization of stress, and not in a diffuse area. F.P.H.

Effect of duration of treatment and concentration of alkali solutions on the resistance of glass. M. A. BESBORODOV. *Glashütte*, **58,** 957 (1928); **59,** 5 (1929).—The effects of soda and caustic soda solutions on three types of laboratory glasses were studied. The alkali solutions were used in various strengths from $1/25N$ to $2N$. The loss in weight of the glass increased in a linear manner with the duration of treatment with solutions of all concentrations. Hyperbolic curves were obtained by plotting time against concentration of solution for a given loss in weight in mg. These curves, which are characteristic of the resistance of the glasses, show great sensitivity of the glass to the weaker solutions. (*Trans. Ceram. Soc.* [Eng.])

Taylor studies on analysis technique of glass raw materials. III. D. JAPHE. *Sprechsaal*, **62** [8], 22 (1929).—A comparative study is made of the known methods of determining the sulphate ingredients with reference to the accuracy and duration of the analysis. The ingredients dealt with are sodium sulphate, free acid, sodium chloride, alumina, iron oxide, calcium sulphate, magnesium sulphate, moisture content, and insolubles. The shortest methods are determined experimentally for two accuracy limits, ± 0.15 to 0.2%, and ±0.5 to 0.7%. The first analysis takes 3 hrs. 7 min. and the second, 2 hrs. 28 min. The results of analyses are given. For previous articles see *Ceram. Abs.*, **6** [12], 390 (1927); **7** [12], 615 (1928). (*Trans. Ceram. Soc.* [Eng.])

Relation of composition of glass to its optical constants. III. T. TAKAMATSU. Osaka Ind. Res. Inst. *Repts. Imp. Ind. Res. Inst.*, **9,** No. 12 (1929).—Optical constants of Na–K glass having the composition of $x/2Na_2O{\cdot}x/2K_2O{\cdot}yCaO{\cdot}6SiO_2$ have been determined. When SiO_2 and CaO are kept constant, the value of n_D increases regularly with the increase of the sum of the molecular concentration of Na_2O and K_2O, the average increase being 0.0010 per 0.1 molecule. If the sum of the molecular concentration of Na_2O and K_2O is below 2.4 molecules against 6 molecules SiO_2, the change of n_D is in a straight line. The increase of the total dispersion is proportional to the increase of the sum of molecular concentration of Na_2O and K_2O, the average increase being 0.000059 per 0.1 molecule. The change of γ $((n_D - 1)/(n_F - n_C))$ is inversely proportional to the sum of the molecular concentration of Na_2O and K_2O, the average decrease being 0.30 per 0.1 molecular increase. When SiO_2, Na_2O, and K_2O are kept constant, the change of n_D is regular; if the sum of Na_2O, K_2O, and CaO is below 2.4 molecules against 6 molecules SiO_2, the change of n_D is in a straight line, the average increase being 0.0027 per 0.1 molecule CaO. The average increase of the total dispersion is 0.000066 per 0.1 molecule increase in CaO. The change of γ is inversely proportional to the increase of CaO, the average decrease being 0.16 per 0.1 molecule increase in CaO. (*C.A.*)

Alkali content of medicinal glass. B. SCHWENKE. *Pharm. Ztg.*, **74,** 261–63 (1929).—The alkali removed from various samples of glass vessels, after $^1/_2$ and $1^1/_2$ hrs. boiling with water, reckoned in mg. of sodium hydroxide per 100 cm.^{2} of surface exposed, is tabulated. Of 10 different samples, from which the alkali removed varied from 0 to 5.8 mg., only three are regarded as satisfactory. (*B.C.A.*)

Temperature coefficient of magnetic susceptibility of glass. W. GERLACH AND N. LITTLE. (Univ. Tübingen.) *Z. Physik*, **52,** 464–65 (1928).—Various glasses (Thüringer, Hartglass, Pyrex, and colored glasses) have large temperature coefficients of susceptibility, which must depend upon the paramagnetic susceptibility of the materials, since their diamagnetic susceptibility is independent of temperature. (*C.A.*)

Fractionated crystallization of technically pure glass. H. JEBSEN-MARWEDEL. *Naturwissenschaften*, **17,** 84 (1929).—Most technical glass has a composition close to 72% SiO_2, 14% CaO, 14% Na_2O (Morey and Bowen), *i.e.*, in the ternary diagram it lies in the field of primary crystallization of β-wollastonite at 1100°. If crystallization takes place, the glass surrounding the crystal will become richer in SiO_2; in this case diffusion is too slow and cristobalite crystals will be formed as soon as the SiO_2 field is reached. This again may cause excess of base and wollastonite until separation finally, after repeated alternation of both crystal species, the eutectic mixture at 725° is reached. From microscopic observations, 4 drawings being given, this is confirmed; the paragenesis of β-wollastonite and cristobalite gives needles of the former more or less surrounded by a felt of the latter, which often appears as an efflorescence. (*C.A.*)

Dependence of alkaline and acid condition of glasses on the concentration of hydrogen ions. O. K. BOTVINKIN AND A. M. TANCHILEVICH. *Z. anorg. allgem. Chem.*, **168,** 356–60 (1928).—Two samples of glass were crushed to 20- to 30-mesh and treated with HCl and KOH solutions. The p_H of the glass after treatment changed with the concentration of the reagent used. (*C.A.*)

Colloid technical review. I. Glass. RAPHAEL ED. LIESEGANG. *Kolloid-Z.*, **44,** 251–58 (1928).—The phases reviewed are the dispersoid chemistry of the glassy state, polymerization, gel formation, devitrification during the manufacturing process, and later, chemical activity, dye-stuff adsorption, frosted and opaque glasses, colored glasses, viscosity and surface tension. (*C.A.*)

Use of trachyte in the manufacture of glass. I. I. KITAIGORODSKII AND S. V. RODIN. *Trans. State Exptl. Inst. Silicates* [Moscow], pp. 3–62 (1928).—On account of the shortage of Na_2CO_3 in U.S.S.R. an investigation was made of the possibility of avoiding the use of alkalis in the manufacture of bottle glass by utilizing natural rocks with an alkaline content. Trachyte deposits being very abundant, a study was made of the behavior of this rock in the course of glass fusion, as well as of the thermic conditions which are most favorable to the process, and of the quantities and qualities of the substances which it would be necessary to add to facilitate the formation of the glass mass while avoiding bubbles, viscous glass, and other defects. The most valuable components of trachyte are K_2O and Na_2O; their contents fluctuate between 5 and 17%; the other components are SiO_2 63 to 73, Al_2O_3 12 to 25, Fe_2O_3 1 to 4, CaO and MgO 1 to 5. All these ingredients contribute to glass formation, but Al_2O_3, which is a hard-melting substance in the presence of Ca and Mg, is contained in excessive quantity. Fe_2O_3 gives the glass a greenish coloration, which is not undesirable in bottle glass. The procedure consisted in taking for experimentation at first a too large quantity of trachyte (since the intention was to use as much trachyte as possible), and then gradually decreasing it and adding in its place increasing quantities of silica sand and of chalk. A good proportion was: trachyte 70% and CaO 20 to 25%. Ten to 12% of BaO introduced into the mixture as $BaCO_3$ gave good results, but if it was introduced as $BaSO_4$ a viscous and imperfect glass was obtained. Another good mixture was trachyte 75%

and CaO·MgO (introduced as dolomite) 25%, whereas $MgCO_3$ was harmful. Other successful mixtures contained: 40 to 55% trachyte, 25 to 30% CaO and CaO·MgO; 35 to 60% trachyte, 25 to 50% CaO and BaO. These experiments were confirmed by operations on a larger scale; under the latter conditions still better results were obtained with mixtures containing either 5% sand or none, the trachyte content being 85 to 88%. The testing data show that all these glass samples resist temperature changes of 50 to 80°. The mechanical properties (resistance to breaking by impact, etc.) were best with samples having the largest trachyte content. The very high resistance to the chemical action of alkalis and of acids, as well as the low linear coefficient of expansion, render the trachyte glass superior to the ordinary lime-alkali glass and even to some kinds of chemical glassware. Trachyte glass can compete with porcelain as insulator. (*C.A.*)

Time-temperature curves of visible devitrification in plate glass. E. ZSCHIMMER AND A. DIETZEL. *Sprechsaal*, **60**, 110, 145, 186, 204 (1927).—A new method is described for exact measurement of the speed of crystallization of crystals in undercooled glasses up to a minimum length of 10. The speed of crystallization, or devitrification time, for crystals from 20 to 200 between 700° and 1140° was measured. The time-temperature curves of devitrification for crystals having maximum lengths of 10, 50, and 100 are given. By the help of these curves the melting and cooling of glass in practice can be regulated so as to avoid visible devitrification. For the glass tested, the critical zone was between 950 and 1050°. (*Trans. Ceram. Soc.* [Eng.])

Volatilization of glass ingredients during melting and fining. F. H. ZSCHACKE. *Glashütte*, **59**, 331 (1929).—A review of the literature is given.
(*Trans. Ceram. Soc.* [Eng.])

Decolorizing pot metal. L. R. *Glashütte*, **49**, 332 (1929).
(*Trans. Ceram. Soc.* [*Eng.*])

Electrical properties of glass. H. KÜHL. *Glashütte*, **49**, 335 (1929).—Elementary principles are dealt with. (*Trans. Ceram. Soc.* [Eng.])

Applications of glass to chemical and allied industries. A. E. MARSHALL. *Glass Ind.*, **10** [7], 166–71 (1929); see also *Ceram. Abs.*, **7** [11], 751–52; [12], 821 (1928).
E.J.V.

Color for glass container. WALDON FAWCETT. *Glass Ind.*, **10** [7], 164–66 (1929).—A single color can not be trade marked but a color expressed in a peculiar or particular form can be. The color raiment of a glass container may be a trade mark in fact if not in name. E.J.V.

German glass industry foreign trade. G. HIRSCHFELD. *Glass Ind.*, **10** [7], 173 (1929).—The German glass industry uses exclusively domestic raw materials. The chief competitors are Belgium and Czechoslovakia, both of which have lower wages. Exports to the U. S. and the Far East have decreased. This industry has mastered the after-war depression and is now building up its export trade in a very energetic and decisive manner. E.J.V.

BOOKS

Springer's Jahrbuch (Kalender) für die Glasindustrie, 1929. 26th year. Edited by LUDWIG SPRINGER. F. O. Müller, Altenburg, Thür. Linen, M 5. (*C.A.*)

Glas-Taschenbuch, 1929. 2 vols. Keramische Rundschau (Tonindustrie-Zeitung). Berlin. (*C.A.*)

PATENTS

Sheet-glass supporting table. FRANK FRASER. U. S. 1,718,342, June 25, 1929. In sheet-glass surfacing apparatus, a plurality of detachably associated tables having upstanding side portions, and a plurality of detachable means arranged transversely

of the tables and coöperating with the side portions for forming a plurality of sheet-receiving recesses.

Grinding head. JOHN C. GIFE. U. S. 1,718,347, June 25, 1929. In sheet-glass surfacing apparatus, means for supporting a sheet to be surfaced, a rotatable surfacing member adapted to rest upon the sheet, a vertical shaft connected at its lower end to the surfacing member, a nonrotatable sleeve surrounding the shaft and carried by the member, a plunger connected to the sleeve and arranged in substantially vertical alignment with the shaft, and a cylinder for snugly receiving the plunger therein, the cylinder having an inlet and an outlet therein by which fluid pressure can be admitted thereto and released therefrom, the inlet and outlet being so positioned that the fluid pressure will act directly upon the upper end of the plunger.

Frosting glass articles. MARVIN PIPKIN. U. S. 1,718,487, June 25, 1929. In an apparatus for frosting glass articles, the combination of a frame, a removable table supported thereon having apertures therein for receiving a plurality of articles, a plurality of receptacles containing treating solutions mounted below the frame, a plurality of nozzles, means for forcing the liquid through the receptacles, means whereby the tables are caused to register so as to bring each of the articles over a nozzle, and intermediate supports carried by the frame for receiving the tables between treatments.

Bottle-transfer apparatus. LEONARD D. SOUBIER. U. S. 1,718,607, June 25, 1929. The combination of a ware-forming machine, a traveling ware carrier element, a chute for directing the initial movement of ware discharged from the machine, a reciprocable frame between the chute and the carrier element, a pair of coacting clapper sections pivoted to and depending from the frame to receive and momentarily check the movement of ware discharged from the chute, means for lowering the frame and clapper sections with the ware, fingers projecting laterally from the clapper sections and transversely of the path of travel of the carrier element, upstanding brackets arranged at transversely aligned points with respect to the path of travel of the ware carrier element, and stops vertically adjustably mounted in the brackets and engageable with the fingers to effect separation of the clapper sections at a predetermined elevation and discharge of ware into the carrier element.

Glass-feeding apparatus. LEONARD D. SOUBIER. U. S. 1,718,608, June 25, 1929. The combination of a container for molten glass having a bottom outlet, two concentric implements projecting into the glass over the outlet, means to actuate periodically one implement at time-intervals of predetermined length to effect a periodic variation in the rate of discharge of glass, and means to actuate the other implement periodically at time-intervals of a different length from the first-mentioned time-intervals.

Glass-forming machine. RICHARD LA FRANCE. U. S. 1,718,651, June 25, 1929. In a glass-forming machine, a blank mold having an open upper charge receiving end, a neck mold coöperating with the lower end of the blank mold, an air motor having a chamber at its upper end communicating with the neck mold cavity, a plunger arranged in the chamber and having a tip movable into and out of the neck-mold cavity by action of the motor, a passageway through the tip-forming communication between the chamber and the neck-mold cavity, and means including a passageway through the motor casing permitting delivery of air pressure to the chamber, the passageway through the tip including interconnected longitudinal and radial openings, the former opening through the outer end of the plunger tip and the latter opening radially into the aforementioned chamber, and an automatic valve adapted at times to close the longitudinal passageway.

Fire finishing glass articles. JOHN MURL LENTS AND FRANK R. MILLER. U. S. 1,718,654, June 25, 1929. The combination of a horizontally traveling conveyer by which a series of articles are brought in succession to a fire-finishing station, a holder

adapted to hold a group of articles at the station, means including a series of burners to apply heat to the upper ends of the articles simultaneously, and means to actuate the article holder at predetermined time-intervals to release one article at a time from the holder and cause a step-by-step advance of the remaining articles in the holder.

Rolled sheet glass. CLEMENT JUNGERS. U. S. 1,718,824, June 25, 1929. A translucent rolled sheet glass one surface having relatively deep V-shaped design forming grooves therein, the walls of which are light refractive, the surface between the grooves being of a light diffusing character.

Leer. JOHN MAYO. U. S. 1,719,897, July 9, 1929. In a leer, in combination, a conveyer for transporting glassware through the leer, an oscillating device, means comprising the conveyer for feeding pieces of glassware into and through the device, and means for actuating the device to arrange the pieces in rows crosswise of the leer.

Manufacturing glassware. WILLIAM EMIL BOCK. U. S. 1,720,029, July 9, 1929. (1) The combination with the outlet opening of a furnace or source of molten glass supply, of a forehearth having a bottom discharge opening for the gravity flow of a stream of molten glass therefrom and adapted to receive glass from the outlet opening, the forehearth being vertically adjustable relative to the outlet opening to vary the depth of glass in the forehearth or to compensate for a lowering of the level of the glass in the source. (2) In combination, means from which molten glass flows by gravity in sheet form, a pair of flexible electrically heated bars disposed at opposite sides of the sheet to surface finish the same, means supporting the bars, and means exerting a longitudinal stretching pull on the bars. (3) In combination, a furnace for molten glass having a discharge outlet in its front, a plate mounted for vertical adjustment at the front of the furnace and having an opening in register with the furnace opening, a housing carried by the plate without its opening and forming a tempering chamber for the glass, the housing having an outlet from which the glass flows in sheet form, a unit carried by the plate at each side edge of the sheet and having chains for prolonged gripping engagement with the sheet, each unit being angularly adjustable transverse to the sheet, means for imparting predetermined feeding movements to the chains of each unit, and means operable to adjust the plate. (4) In combination, means from which molten glass flows in sheet form, a width controlling unit disposed at each side edge of the sheet and having a pair of sheet-edge gripping chains, the chains of each unit being angularly adjustable relative to the line of movement of the sheet and being adjustable relative to each other, means for driving the chains in accordance with the movement of the sheet, and sheet severing bars connecting the chains of different units and operable to coöperate periodically in pairs to slit the sheet transversely, the bars having longitudinal sliding connection with the chains.

Glass-charging device. ALBERT F. TREMBLAY. U. S. 1,720,496, July 9, 1929. (1) A charge forming device comprising a reservoir for molten glass, charge-forming and charge-severing means including shears, cam means to close the shears, and pneumatic means to open the shears. (2) A charge-forming device comprising a plunger, a rotary cam concentric with the plunger, a yoke concentric with the plunger and having a roller for riding on the cam, the yoke being slidably mounted with respect to the plunger and cam, a nut having means whereby it may be secured at any one of a number of points on the plunger, a screw arranged through the nut and being mounted for rotary movement in the yoke but restrained from axial sliding movement, and means connected to the screw for rotating the same to adjust the yoke.

Drawing sheet glass. CLIFFORD A. ROWLEY. U. S. 1,720,527, July 9, 1929. In an apparatus for drawing sheet glass, an internally cooled metallic loop surrounding the sheet at its source, the end portions of the sides of the loop having a narrower passage

therebetween than the central portions, and the molten glass forming the sheet edges being drawn through these narrow passages in contact therewith.

Glass-cutting apparatus. JOHN L. DRAKE. U. S. 1,720,546, July 9, 1929. In sheet-glass cutting apparatus, means for supporting a moving sheet of glass, a stationary support, a movable frame carried thereby and arranged above the sheet, means carried by the frame for engagement with the free end of the moving sheet to be cut for effecting movement of the frame therewith, and a cutter guide carried by the frame and extending across the sheet.

Drawing sheet glass. ENOCH T. FERNGREN. U. S. 1,720,547, July 9, 1929. The method of forming sheet glass, consisting in flowing three streams of glass downwardly, chilling one of the outer streams, heating the other outer stream and merging the three streams to form the source from which the sheet is drawn downwardly.

Manufacture of glass articles. SYDNEY HUNT. U. S. 1,720,552, July 9, 1929. In machines for the manufacture of glass articles having a parison mold adapted to be lowered to a receptacle containing molten glass in order to pick up a charge of glass and then to be raised therefrom; and having a knife adapted to cut off the trailing glass from the bottom of the parison mold, when this latter is raised; a construction including a movable stop which is adapted to arrest the rise of the parison mold in an intermediate position and to form a reaction abutment to take the upward thrust of the knife during the cutting, together with means for removing the stop after such cutting for the purposes set forth.

Glassware machinery. ROBERT FREDERICK HALL. U. S. 1,720,598, July 9, 1929. In a rotary machine of the type described for the manufacture of glass articles, the combination of a central stationary column, a table rotatable about such column, means for rotating the table, a plurality of mechanisms for making blown glass articles mounted radially upon the table, each such mechanism including a casing which carries a divided finishing mold and operating parts thereof and is provided with a radially extending bore, the end of the casing comprising a smooth annular surface provided with a circumferential groove in communication by means of a pipe with sources of suction and air pressure, a sleeve rotatable in the before-mentioned bore and provided with a smooth end surface coöperating with the grooved surface at the end of the casing, the sleeve carrying the blowing head connected through a suitable valve chamber with a pipe, the orifice of which corresponds with the before-mentioned groove in all positions of the turnover mechanism, the sleeve being also provided with a divided neck mold, an inner sleeve rotatable with and capable of limited longitudinal movement within the first-mentioned outer sleeve and carrying the pivots for the halves of the parison mold, and an inner plunger longitudinally slidable within the inner sleeve and connected appropriately to the halves of the parison mold, all for the purposes set forth.

Glass blowing. S. HUNT. Brit. 309,423, June 6, 1929. Relates to rotary machine of the suction-gathering type having combined blowing and suction heads which coöperate with ring molds and through which the mouth-forming plugs enter the ring molds. Each head is formed as a hollow casting provided with passages connected to sources of suction and of compressed air, and it is open at the top to allow a plug to pass through into the ring mold. The invention consists in providing the head with a rotary valve which, in one position, leaves a passage for the insertion and withdrawal of the plug and in another position closes the passage, cuts off the connection with the suction chamber and allows the admission of blowing-air to the parison.

Glass annealing leers. NAAMLOOZE VENNOOTSCHAP MAATSCHAPPIJ TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Brit. 309,444, June 6, 1929. Glass plates are delivered from a rolling machine to a roller conveyer arranged parallel to a similar conveyer in a leer, means being provided for supporting the plates during transfer from

one conveyer to the other. The rollers at the end of the conveyer are inclosed in a chamber and are adapted to be rotated alternately in opposite directions, this arrangement permitting the plates to be retained in the chamber until they are sufficiently rigid to be fed to the leer. The transfer device comprises bars arranged between the rollers and supported by wheels mounted on vertically movable bars, the latter being raised and lowered by interconnected levers or by eccentrics.

Annealing glassware. AMSLER-MORTON CO., W. A. MORTON, AND P. L. GEER. Brit. 309,511, June 6, 1929. In a tunnel leer for annealing glassware, of the kind having a heating flue disposed within the tunnel adjacent the floor, the temperature is regulated toward the discharge end by withdrawing gases from the heating flue through one or more spaced outlets and by withdrawing some of the tunnel atmosphere, cooling it, and then returning it to the tunnel.

Glass-annealing leers. AMSLER-MORTON CO., W. A. MORTON, AND P. L. GEER. Brit. 309,528, June 6, 1929. In a glass-annealing leer having a heating flue located within the leer adjacent the floor, the ware is carried through the leer by an endless conveyer, both runs of which are disposed within the leer above the heating flue.

Glass furnaces. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE AND A. HERMANSEN. Brit. 309,974, June 12, 1929. (1) A method of making plate glass consists in using a furnace containing a small number of pots, *e.g.*, four, the furnace being a known type of recuperative furnace having a central burner. When the glass is melted and cast every 24 hrs., the use of the small furnace allows a longer time for the refined glass to cool down to the casting temperature than with a large regenerative furnace as usually used. (2) A furnace suitable for carrying out the method comprises a body having a central burner or eye which receives gas from a built-in producer. The burnt gas passes from the body through ports into two main conduits and thence through recuperator chambers to a stack. A glass pocket may be provided below the eye, and cooling-channels may be formed in the siege.

Forming plate glass. J. PRIBIK AND R. PRIBIK. Brit. 309,993, June 12, 1929. Plate glass is made by selecting normal sheets of ordinary glass and then polishing them with a suitable medium, such as moist emery. The glass selected is preferably that made by the Fourcault or Libbey-Owens processes.

Glass blowing. F. ECKERT. Brit. 310,421, June 19, 1929. In the manufacture of bottles or other hollow-ware, air is blown into the interior of an article during its formation in the molds in order to cool the glass internally in addition to the external cooling which is effected by contact with the molds and by exposure to the air. Apparatus for carrying out the process comprises a blowhead secured to the lower end of a tube which is moved vertically by the piston of a pneumatic cylinder. Another tube passes through the tube and projects below the blowhead. The upper end of the tube is connected by a flexible pipe with a valve chest which controls the admission of compressed air to the pipe. When the blowhead is lowered on to a mold, an arm on the tube opens the valve and allows air to blow through the tube into the interior of the parison contained in the mold. A spring-loaded ball valve allows the air to escape through passages in the blowhead, the pressure on the valve being adjusted to delay the escape of air until the required pressure has built up within the parison. The blowhead may thus be used for expanding the parison within the mold as well as cooling it internally. Two or more of such blowheads may be used in connection with a double-table forming-machine.

Glass feeding. F. ECKERT. Brit. 310,422, June 19, 1929. A device for feeding glass to the molds of a forming-machine comprises a forehearth having an outlet aperture, means for bringing each mold into contact with the aperture, means for exerting suction within the mold for filling it directly from the forehearth, and means for apply-

ing suction above the surface of the glass in the forehearth in order to stop the flow of glass during the time that one mold is being replaced by another.

Gathering molten metal. HARTFORD-EMPIRE CO. Brit. 310,469, June 19, 1929. Relates to a method of causing a circulation in a body of glass from which charges are gathered by suction. The invention consists in providing a device which stirs the glass beneath the surface at the gathering point, and draws the surface glass, chilled by contact with the mold, downward into the body of glass. The rotation of the conical end tends to rotate the glass around the stem of the stirrer, and the surface glass at the gathering point is continually drawn down into the body of the glass and reheated. A fresh surface of hot glass is thus maintained at the gathering point.

Compound transparent sheets. DU PONT VISCOLOID CO. Brit. 310,475, June 19, 1929. To prevent discoloration of compound united sheets of glass and plastic material, the plastic material is formed with less than 12% or entirely without camphor and plasticizers or solvents are used in making the plastic sheet which are unaffected by actinic light. Examples of such plasticizers are the fatty acid esters of the aliphatic alcohols, the alkyl ethers of polyhydric aliphatic alcohols and mixed ethers and esters, and certain carbocyclic acid esters, *e.g.*, the alkyl phthalates. The plastic must be moldable at from 90 to 125°C and when finished should have a tensile strength of 5000 to 8000 lbs. per sq. in. at 60°F and the solvent used should have a boiling point above 95°. Four examples of plastics are given: (1) pyroxylin 100, amyl acetate 16.6, triacetin 16.6, urea 0.25; (2) pyroxylin 100, amyl acetate 33, urea 0.25; (3) pyroxylin 100, triacetin 25, urea 0.25; (4) pyroxylin 100, camphor 9.6, amyl acetate 0.25, urea 0.25. Other bases than pyroxylin such as cellulose acetate, cellulose ether, starch derivatives may be used.

Glass drawing. SOC. ANON. DES ATELIERS DE CONSTRUCTION ET FONDERIES DE JEUMONT ANCIENS ETABLISSEMENTS T. HAUT. Brit. 310,952, June 26, 1929. Relates to sheet-drawing apparatus of the type in which the sheet is drawn vertically upward between pairs of opposed rollers, one roller of each pair being mounted in fixed bearings while the other is carried by counterbalanced bell-crank levers. It is stated that if an obstruction, such as a stone, passes between the rollers, the consequent tilting of the movable roller out of parallelism with the fixed roller causes undue friction between the shaft of the roller and its bearings, and there is unnecessary resistance to the movement of the roller. The invention consists in journaling the shaft of the movable roller in bushes which are spherical over the part of their exterior which is in contact with the bearing blocks. The bushes are thus free to roll in the blocks, and the roller can be inclined to its supporting levers. These levers are also mounted on knife edges, secured to the frame of the machine, in order that the roller may offer less resistance to displacement.

Compound transparent sheets. G. E. HEYL. Brit. 311,151, June 26, 1929. When uniting sheets of glass and cellulose derivative by direct fluid pressure, the edges of the compound sheet are sealed with rubber solution mixed with sulphur, or other similar resinous solution which is insoluble in the pressing fluid to prevent entry of the fluid between the sheets. Excess of adhesive is removed by pressure between rollers on the cellulose derivative sheet or on all the sheets before sealing.

Crucible for melting and refining glass. L. BRUHIÈRE. Belg. 350,091, April 30, 1928. The crucible comprises two open melting compartments, partially superposed and communicating with each other; also two completely covered refining chambers, one on each side of the lower melting chamber, with which they are connected by means of openings in the bottom of the separating walls. By this arrangement either of the melting chambers can be used, and the same or different temperatures can be maintained in the two refining chambers. (*C.A.*)

Furnace for annealing glass, etc. UNITED GLASS BOTTLE MANUFACTURERS, LTD. Fr. 645,005, Oct. 27, 1927. (*C.A.*)

Glass-making furnace. GENERAL ELECTRIC CO., LTD. Fr. 645,157, Dec. 5, 1927. (*C.A.*)

Heavy Clay Products

Brick road paving. ANON. *Brit. Clayworker*, **38** [446], 88–91 (1929).—The object of the investigation, undertaken by a commission of 4 engineers appointed by the Natl. Paving Brick Mfrs. Assn. (United States), was to obtain an up-to-date picture of the trend of highway paving business in the territory surveyed and also to investigate the brick paving situation throughout the country. The report gives the results of the commission's findings. R.A.H.

Storage of clay and shale. ANON. *Brit. Clayworker*, **38** [446], 102 (1929).—When only one clay or shale of constant composition is used the problems of storage relate almost wholly to providing bins or floors large enough to accommodate it, but when several materials are used and have to be mixed to secure a uniform product, their behavior in the bins or on the floor is a matter of importance. The article discusses how the coarser particles are separated from the finer ones when a mixture of ground clay or shale is discharged from a conveyer belt into a bin and how these same particles act when drawn through the bottom opening of the bin. To prevent "unmixing" or to remix the materials as far as possible the lower sides of the hopper should be at an angle of 45°. Where practical it is beneficial to empty one hopper before putting any more material into it. This yields a more uniform product. R.A.H.

Brick as modern building material. AILWYN BEST. *Brit. Clayworker*, **38** [446], 103–104 (1929).—B. discusses brickwork from the artistic viewpoint. R.A.H.

Reorganization of out-of-date brickworks. ANON. *Brit. Clayworker*, **37** [438], 262–63; [439], 293–95; [440], 334–35 (1928); [441], 382–84; [442], 415–16; [443], 452–53 (1928); **38** [444], 16 (1929).—In the reorganization of the out-of-date brickworks, the question of the kiln equipment is important. In addition to the main features of manufacture, mostly of a technical character, there are minor matters in which economies may usefully be effected provided that the manufacturing side is suitably reorganized. Such items as economy and suitability of buildings for housing the plant, means of conveyance and transport, and distribution of power in large works, are best dealt with by specialists. Viewed from a modern technical standpoint, a large proportion of the brickworks in the country are out-of-date. The advances in technical knowledge and the improvements in labor-saving devices give such advantage to a newly designed works, that the older works will some time in the near future find themselves outclassed unless they acquaint themselves with the new technical improvements. This series of articles suggests ways and means of reorganizing and bringing up-to-date small and moderate size brickworks. R.A.H.

Effect of treatment of the test piece on crushing strength of sand-lime brick. DITTMER. *Mitt. a. d. Materialprüfungsamt*, **44**, 108 (1927).—Sand-lime brick and test pieces prepared therefrom were subjected to different treatment for drying and time of storing. Test pieces which had been stored a considerable time, whether they had been previously oven-dried or not were weaker than samples tested immediately after having been oven-dried to constant weight. The following method of preparation is suggested: the brick are dried to constant weight in an oven and then prepared. The test pieces are dried to constant weight and tested after having been stored in the room for two days. (*Trans. Ceram. Soc.* [Eng.])

Manufacture of face brick. ANON. *Ziegelwelt*, **60**, 100 (1929).—A brief account is given of the manufacturing processes, methods of producing different colors with different clays, etc. (*Trans. Ceram. Soc.* [Eng.])

Cracks in clayware. P. N. GRIGORJEW AND P. J. GALKIN. *Keram. Rundschau*, **35**, 839 (1927).—Cracks may develop in ordinary clayware, brick, and tile during (1) the shaping or molding process, (2) drying, (3) the smoking period, (4) the firing and cooling period, or (5) while the finished ware is stored up. The causes of cracking during these five processes are outlined. (*Trans. Ceram. Soc.* [Eng.])

Cause and prevention of scumming on brick. H. HIRSCH. *Tonind. Ztg.*, **51**, 1044 (1927).—Sulphates are the main cause of scumming, and the preventive measures suggested are (1) selection of raw materials, (2) removal of gypsum and pyrites, and (3) addition of barium compounds to decompose the sulphates. Other points mentioned are (1) setting the brick dry in the kiln, (2) complete smoking, (3) avoidance of fuels containing sulphur, and, (4) wherever possible, firing periodically in a reducing atmosphere. (*Trans. Ceram. Soc.* [Eng.])

Calcium-silicate brick process. ANON. *Ind. Chemist*, **4**, 32 (1928).—The process of manufacturing sand-lime brick is described. Sand is mixed with 5 to 10% of well-slaked lime and a little water, and the mixture is pressed into brick, which are heated for 4 to 8 hrs. in an autoclave or cylinder, at 120 to 180 lb. pressure. Similarly with ash, clinker, blast-furnace slag, etc., the material, ground moderately fine, is mixed with slaked lime. The lime combines with the free silica or unsaturated silicates. In the manufacture of slag brick, there must be no trace of quicklime. In another process, the ash, slag, etc., is mixed with cement instead of lime. (*Trans. Ceram. Soc.* [Eng.])

Cause of failure of brickwork. E. DONATH AND H. LEOPOLD. *Chem.-Ztg.*, **53**, 277–79 (1929).—Failure of mortar and plaster has been traced in the case investigated to the use of (*a*) water containing relatively large amounts of chlorides and nitrates; (*b*) lime derived from a limestone containing iron and aluminium oxides and silica; (*c*) too high a proportion of sand. (*B.C.A.*)

Face tile for building. ANON. *Brick Clay Rec.*, **75** [1], 28 (1929).—Advantages of the face tile are permanence, fire resistance, immunity to weather, etc. E.J.V.

Effect of frost on raw and fired material. ANON. *Ziegelwelt*, **60**, 97 (1929).—In the brick industry there are occasions when the expansive force exerted by water as it freezes is welcomed and even intentionally produced, while at other times it is dreaded, and protective measures have to be taken against it. The effect of frost on clay during weathering is to loosen its structure, and it is therefore advantageous. To resist the action of frost a fired product should contain a sufficient number of large pores, in which the water has room to expand on freezing without exercising a disruptive force on the surrounding material. (*Trans. Ceram. Soc.* [Eng.])

Influence of the moisture-content of building materials. R. E. STRADLING. Dept. Sci. and Ind. Research, *Bull.*, No. 3; *Tonind.-Ztg.*, **52** [74], 1508 (1928). F.P.H.

Handling heavy sewer pipe. ANON. *Brick Clay Rec.*, **75** [1], 29–30 (1929).—A method of handling 21-, 24-, 27-, and 30-in. pipe by use of a roller conveyer and a small monorail crane is described. E.J.V.

Clayworking machinery. ANON. *Tonind.-Ztg.*, **52** [74], 1492–94 (1928).—Some of the latest improvements made in the design of auger machines are described and illustrated. F.P.H.

American automatic brick-cutting machines. CARL HÜTTER. *Tonind.-Ztg.*, **52** [71], 1439–43 (1928). F.P.H.

Beauty of brick. ELEANOR RAYMOND. *Good Housekeeping*, **88** [6], 47 (1929).—Brick is a favorite material for houses because of its practicality as well as its beauty. The beauty of brick as a medium for architectural expression depends on a number of factors: the size, texture, and color of the brick, the color of the mortar, the character of the joints, and the kind of bond used. A nontechnical discussion of these various factors is given. E.J.V.

Plants in the southwest. ANON. *Brick Clay Rec.*, **75** [2], 86–89 (1929).—Two plants in the southwest which have recently improved their methods are the Wewoka Brick & Tile Co., at Wewoka, Okla., and the New Mexico State Penitentiary Plant at Santa Fe, the former, a new company, and the latter an old established plant wherein all old equipment has been scrapped in favor of new. Both plants are described in detail. E.J.V.

"Natco" fireproofing. ANON. *Brick Clay Rec.*, **75** [1], 18–25 (1929).—One of the largest plants producing structural clay tile and fireproofing from surface clay is the National Fireproofing Co., at Hobart, Ind. This plant is one of the outstanding achievements in the modernizing of the company's plants, being electrified throughout and having an unusually fine and complete clay preparation unit and clay storage. Full details of construction and equipment of this plant are given. E.J.V.

Economic management of old brickworks. ANON. *Süddeut. Tonind.*, **11**, 22 (1929).—Suggestions are made regarding the modernization of plants during the winter season. (*Trans. Ceram. Soc.* [Eng.])

BOOKS

Earthquakes and Building Construction. Clay Products Institute of California. 110 pp., 103 photographs. Conclusive evidence on the soundest of authority and past performance, that properly constructed buildings of clay products withstand earthquake shocks is contained in this book. Photographs and correct historical data of many disasters prove that brick and tile are among the leaders in withstanding the tremors of the earth's crust. Data by experts on the design of buildings to resist seismic disturbances are given. There are tables, charts, and calculations showing the stresses and strains imposed upon a building during earth movements. One chapter is devoted to the hollow masonry unit in earthquake resistant design. Recent tendencies of building construction and photographs of some of the most modern and outstanding buildings in the country, with data as to the materials used in their construction are given. Brick, terra cotta, and structural clay tile figure prominently in these structures. Reviewed in *Brick Clay Rec.*, **75** [2], 95 (1929). E.J.V.

Building Craftsmanship in Brick and Tile and in Stone Slates. NATHANIEL LLOYD. Cambridge University Press, 15s; reviewed in *Brit. Clayworker*, **38** [446], 96 (1929).—L. has dealt with the finer points of craftsmanship which distinguish a building of merit from the commonplace. The book is a useful guide to the brick and tile-maker who is not infrequently blamed for the lack of variety in the size and color of the materials he supplies. The manufacturer will find explained the reasons why the use of certain shapes and arrangements of brick and tile produce effects which give a building charm and originality, and why the neglect of these small elements will mar the whole effect. R.A.H.

PATENT

Building tile. JAKE L. TREMPER. U. S. 1,720,306, July 9, 1929. A building tile of rectangular form having parallel upper and lower walls, self-sustaining vertical end walls parallel to each other and at right angles to the upper and lower walls, two brace webs between the upper and lower walls dividing the space between the end walls substantially into equal thirds, and diagonal reinforcing webs at the corners, the reinforcing webs extending from substantially the centers of the vertical walls to points close to the junction of the side walls with the brace webs and providing relatively small cells to serve as mortar locks.

Refractories

Graphite. I. PAUL M. TYLER. Bur. Mines, *Information Circ.*, No. 6118, 44 pp. (1929).—Natural graphite, also known as plumbago or black lead, is a black lustrous mineral with a greasy feel. It is classed either as crystalline or as amorphous. Since

all graphite is crystallized carbon, amorphous graphite is actually not amorphous, but cryptocrystalline. The source and uses of vein, flake, amorphous, and artificial graphite are discussed. In addition, the chemical and physical properties, mode of occurrence, origin, prospecting and development, mining methods, concentrating and refining of natural graphite, and the manufacture of artificial graphite are given in detail. The world production and consumption of graphite and domestic production of various kinds are listed together with imports and exports. An excellent bibliography is attached. R.A.H.

Cracks in silica bricks. ANON. *Brit. Clayworker*, **38** [446], 93–94 (1929).—Wastage due to cracks in silica brick amounts in some cases as high as $^1/_3$ of total production as compared to a loss of 2 or 3% in well-controlled works. The raw material is a common cause of cracking. Quartz particles in some silica rocks are under such internal strain that they crack on heating. Coarse particles are changed more slowly into cristobalite and tridymite than are finer particles so that it is desirable to have present in the brick at least 50% of particles less than 0.02 in. in diameter and none should be more than $^1/_8$ in. in diameter. The lime used as a binder sometimes causes cracks, especially if it has been imperfectly sieved, insufficiently slaked, or poorly mixed with the crushed grog. A slip should be made of the lime and passed through at least an 80-mesh sieve. A common cause of cracking is the slight bending of the brick as it leaves the mold, a defect which is hard to detect until the brick is fired. Cracks often occur in drying and they are so fine that it is frequently impossible to see them before the brick are fired. To secure the best results brick should be dried rapidly at a fairly high temperature. A clear "ring" in a dry silica brick is an excellent sign of quality. The rate at which the temperature rises when firing is important and should not be less than 140 hrs.; 26 to 30 days are usually required to make a complete cycle in a kiln. Firing to cone 18 is desirable. Ample draft, but not too keen, is desirable during firing and fires should not be allowed to die down too low before stoking and on no account should there be much space between the top of the fuel and the arch through which spare cold air can so easily enter the kiln. Carelessness or ignorance in cooling the kiln may cause many bricks to crack. The wicket should not be opened to hasten cooling. Cooling between 600 and 180°C should be slow. R.A.H.

Durability of various parts of glass furnaces with special reference to refractories. W. GROOTHOFF. *Sprechsaal*, **62** [18], 311–13; [19], 331–33 (1929).—The following guide lines for masonry are given: (1) The larger the change of temperature to which the masonry is subjected, the smaller should be the shapes. (2) Masonry, being subjected to change of temperature, should be built of basic brick. (3) Joints must be used systematically, be proportioned right, and of proper composition. (4) All arches must permit expansion. There are also explained the necessary requirements for all parts of a tank furnace including suspended ceilings, burners, recuperators, etc. T.W.G.

Resistance of refractories to glass and molten slag. OSKAR LECHER. *Sprechsaal*, **62** [22], 390–92 (1929).—The methods used by the A.S.T.M. and the one recommended by C. I. Rose (*Jour. Amer. Ceram. Soc.*, **6** [12], 1242 (1923)) are discussed and criticized. In another method used by L., partly ground test cube series are heated and exposed to dripping glass. Full data as to the various compositions and temperatures used are given. Conclusions are: (1) water absorption and wear, as a rule, decrease with an increase of temperature for one certain refractory of the same composition; (2) the chemical analysis (especially the determination of Al_2O_3) as well as the fusion point are of no value for the determination of resistance. (3) the finishing temperature is of limited value only; refractories with coarse grain must be fired high (to above cone 14), while other finely-grained refractories with an average Al_2O_3 content obtain the

identical resistance below cone 8, (4) certain fluxes, resulting in a denser structure, are beneficial; cast refractories are better than plastic refractories. The finishing of refractories, as practiced in some factories, with hammer and chisel, is harmful. T.W.G.

Load test of refractories. II. MINORU NAKAMOTO. *Jour. Jap. Ceram. Assn.*, **36** [423], 94–103 (1928).—Experiments have been made on the load-bearing property of Kokaseki, a pumice-like volcanic rock produced in Niishima Island of Izu. Analysis and softening temperature are:

TABLE I

Specimen	Silica	Alumina	Ferric oxide	Lime	Magnesia	Alkalis (by diff.)
Light reddish brown	78.27	14.66	3.71	1.23	0.81	1.32
White	77.41	13.34	2.49	1.17	0.77	4.82

TABLE II

Load	Max. safe temp.	Softening began at	Compressed 25% in height at
1 kg./sq. cm.	788°C	824°C	990°C
2 kg./sq. cm.	700°	771°	953°

The specimens show no abnormal expansion in heating and behave in softening like silica brick. S.K.

Softening temperature of fire brick under load. SEIJI KONDO. *Jour. Jap. Ceram. Assn.*, **36** [425], 208–17; [431], 519–27 (1928).—The softening behavior of 48 different fire bricks made by 15 manufacturers under a load of 2 kg./sq. cm. has been studied:

TABLE I

	Refractoriness (Cone)	Temp. corresponding to the following submission of specimens in height (°C). Av. figure shown in brackets			
		(0%)	(0.1%)	(0.5%)	(5%)
25 Grog brick (2 brick under cone 26 excluded)	27.5–36	1054–1405 [1244]	1081–1455 [1282]	1149–1502 [1325]	1220–1636 [1421]
8 Roseki brick	31–35	1057–1312 [1178]	1090–1341 [1216]	1147–1386 [1261]	1278–1484 [1366]
7 Silica brick	34	1501–1633 [1599]	1512–1658 [1623]	1527–1683 [1640]	1533–1726 [1654]
1 Chrome brick	33	1361	1389	1457	1614
1 Magnesia brick	33.5	1316	1331	1456	1586
1 Alundum brick	38	1380	1399	1425	1474
2 Carborundum brick	Over 38	1456–1604 [1530]	1518–1639 [1579]	1553–1665 [1609]	1622–1720 [1671]
3 Insulation brick	10.5–26	813–827 [819]	856–882 [866]	890–946 [912]	1027–1046 [1038]

Forms of height-temperature curves, relation between the softening temperature and refractoriness, and that between softening temperature and chemical composition are discussed. S.K.

Heat-resisting properties of brick, tile, and cement ware. SEIJI KONDO. *Jour. Jap. Ceram. Assn.*, **36** [431], 528–36 (1928).—Tests were made on the refractoriness and softening behavior under a load of 2 kg./sq. cm. of common brick, hollow tile, paving brick, wall tile, stove tile, cement-asbestos slate, and various mixtures of a Portland cement and the standard sand or a sand of the Tama River. (Table I.)

TABLE I

	Refractoriness (cone)	Temp. corresponding to the following submission of specimens in height (°C)			
		(0%)	(0.1%)	(0.5%)	(5%)
Brick made of loam	7–12	770–1026	821–1044	881–1059	901–1086
Stoneware tile	14–28	1040–1185	1111–1210	1148–1237	1243–1294
Cement ware	10–31	733–1088	779–1103	939–1230	1140–1292

Softening temperature and curves of the cement-asbestos slate are markedly influenced by the direction of pressure. Specimens made of the neat cement or the Portland cement and the standard sand show peculiar softening curves probably owing to changes other than melting. S.K.

Quality of Endai fire clays. MASAJI KAJIWARA. *Jour. Jap. Ceram. Assn.*, **36** [422], 58–65 (1928).—The quality of fire clays which have been used by the firebrick plant of the Anzan Steelworks since Oct., 1926, when it was erected, is described. (1) *Endai Grog Clay:* The clay is a very compact shale and has an oily feel. It is vitrifiable and melts at cone 34. The resistance to the action of a slag has been tested for brick made of its grog and the Endai clay described in (2). The grog was slag-proof, being dense and smooth, while the binding clay was badly corroded. Brick rich in fine grog were excellent regardless of their porosity. (2) *Quality of Plastic Endai Clay Compared with Fukushu Clay:* In chemical composition and refractoriness, the Endai clay resembles the best Fukushu clay which is widely used in Japan (Table I).

TABLE I

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Ignition loss	Refractoriness
Endai clay	42.44	38.41	2.84	0.57	0.34	16.48	Cone 33
Fukushu clay	44.40	38.36	2.49	0.37	0.48	15.43	Cone 33

The Endai clay is finer and more plastic, however, than the Fukushu clay. S.K.

Sillimanite-cyanite. HANS HIRSCH. *Tonind.-Ztg.*, **52** [75], 1512–14 (1928).—A report is made of the investigation of the properties of raw sillimanite and sillimanite refractories. The expansion curve for raw sillimanite is irregular, caused by various transformations that the mineral undergoes. The commercial material begins to soften under load at 1500°C and is completely melted at 1810°C. The properties of the commercial material are compared with those found in the literature for the pure minerals.

	Hardness Mohs' scale	Specific gravity	Mean index of refraction
Sillimanite	6–7	3.2	1.660
Cyanite	5–7	3.5–3.7	1.720
Andalusite	7–7.5	3.1–3.2	1.638
Commercial material tested	5–7	3.5–3.7	1.725*

* Probably due to TiO_2 and Fe_2O_3 present in mineral.

A sillimanite refractory was made consisting of 1 part by weight of bond clay and 2 parts by weight of sillimanite and the material was fired at cone 10. The following properties were determined on the refractory. Chemical composition: SiO_2 41.8%, $Al_2O_3 \cdot TiO_2$ 57.2, Fe_2O_3 0.6, CaO 0.4; refractoriness, cone 37; absorption, 11.1% of dry weight. Softening behavior under load: softening begins at 1500°C completely fused at 1820°C.

EXPANSION BEHAVIOR

Temp. interval	Coeff. $\times 10^{-6}$	Temp. interval	Coeff. $\times 10^{-6}$
20–100	3.1	600– 700	7.2
100–200	6.3	700– 800	13.5
200–300	0.0	800– 900	7.2
300–400	6.3	900–1000	5.4
400–500	7.2	1000–1100	4.3
500–600	1.9	1200–1300	13.4
		1300–1400	−0.3

F.P.H.

Testing refractories for use in crude oil and coal firing. PETER P. BUDNIKOFF. *Tonind.-Ztg.*, **52** [82], 1636–38 (1928).—An outline of tests carried out on refractories

to determine their suitability for use where crude oil or coal is to be used as fuel is given. The refractories consist of mixtures of two Russian clays with 25% grog additions and are designated "half-acid" refractories. F.P.H.

Discussion of "Properties of refractory clays for glass industry." G. GEHLHOFF, H. KALSING, K. LITZOW AND M. THOMAS. *Glastech. Ber.*, **6** [10], 579–81 (1929); see also *Ceram. Abs.*, **8** [8], 586 (1929). E.J.V.

Ceramics of highly refractory materials. I. Forms of zirconium dioxide. O. RUFF AND F. EBERT. *Z. anorg. Chem.* **180,** 19–41(1929).—X-ray investigation shows that the ordinary monoclinic form of zirconium dioxide has the lattice constants a = 5.17, b = 5.27, c = 5.31Å, and β = 80.8°, and has d 5.68, but at about 1000° undergoes a reversible transformation into a tetragonal form, having d 6.10, and a = 5.07 and c = 5.16Å, to which change the destruction of vessels made from the pure oxide when heated at high temperatures must be attributed. The oxide prepared by heating the nitrate, oxalate, or basic chloride below about 600° is tetragonal, but metastable, becoming monoclinic above 600°. If, however, the salt is heated with at least 10 g.-mol. % of magnesium oxide at about 1400°, there is formed an oxide with a cubic lattice, which, as it does not change on cooling, is a suitable ceramic mass for the production of articles required to undergo very wide variations in temperature without fracture or deformation. A similar result is obtained by heating the monoclinic oxide at 1700° with as little as 4 g.-mol. % of magnesium oxide. The maximum amount of magnesium oxide which the zirconium oxide lattice will take up corresponds with the formation of a compound $Mg_2Zr_3O_8$. The oxides of scandium, yttrium, and calcium, and cerium dioxide have the same effect as magnesium oxide. (*B.C.A.*)

Corrosion of crucible in glass manufacturing. MASAJIRO WATATANI. *Repts. Imp. Ind. Research Inst.* [Osaka, Japan], **9** [6], 1–31 (1928).—Twenty-one kinds of crucibles were made by combination of domestic and foreign clay and minerals; the degree of corrosion caused by the action of Na_2O–PbO or K_2O–PbO glass was determined by the macroscopical examination of the crucible and also by the analyses of the glass after a definite time-interval of heating with molten glass. The corroding action of Na_2O–PbO glass was greater than that of K_2O–PbO glass. The higher the temperature of heating of the crucibles previous to the pouring of the molten glass, the greater was the corrosion. Addition of feldspar to the ingredients in the preparation of the crucibles increased the resisting power of crucibles to corrosion. The samples made from German clay had a greater resistance to corrosion than those made from domestic clay. (*C.A.*)

Refractory linings for small combustion chambers. C. P. F. WAIDLER. *Fuel Oil,* **7** [8], 25–26, 118 (1929).—Method of building forms and applying monolithic linings to small oil furnaces is described. (*C.A.*)

Steel-making refractories. I, II. E. R. WALKER. *Chem. Eng. Mining Rev.*, **21,** 93–98, 133–47 (1929).—Methods of testing are given for refractoriness, apparent porosity, contraction or expansion, crushing strength, refractoriness under load, spalling, and slagging. Graphs are shown giving refractoriness, heat conductivity, and thermal expansion of fireclay and silica brick under load. The total impurities in clays should not exceed 4%. The analyses, porosity, and apparent specific gravity of two Australian-made sleeve bricks are: SiO_2, 72.026 and 75.04; Al_2O_3, 24.64 and 20.74; Fe_2O_3, 1.59 and 2.76%; CaO, trace and nil; MgO, 0.41 and 0.41%; ignition loss, 0.48 and 0.10; porosity, 21.40 and 27.65; apparent specific gravity, 2.02 and 1.91. The analysis and porosity of stoppers most generally used are SiO_2, 47.13 and 47.01; Fe_2O_3, 3.45 and 5.40; Al_2O_3, 20.13 and 27.01; CaO, 0.14 and 0.17; MgO, 0.09–0.20; C, 29.10 and 19.77; porosity, 30.25 and 33.15. Silica and neutral refractories are discussed. (*C.A.*)

Refractory materials: their uses in vertical retorts. A. T. GREEN. *Gas World,*

89, 554 (1928).—The properties of refractories are outlined in a general way in relation to the construction and operating requirements of retorts.

(*Trans. Ceram. Soc.* [Eng.])

Refractories in the gas industry. E. W. SMITH AND H. M. SPIERS. *Gas Jour.*, **184,** 729 (1928); *Gas World*, **89,** 579 (1928).—Requirements expected of refractories for the modern gas industry are: constancy of volume, freedom from spalling, refractoriness under load, chemical stability, mechanical strength, thermal conductivity, and good shape. The factors are discussed. (*Trans. Ceram. Soc.* [Eng.])

Properties of some special refractories. M. F. BEECHER. *Forging, Stamping, Heat Treating*, **13,** 456 (1927).—Mullite is made by fusing a mixture of silica sand and bauxite, or alumina, in an electric furnace. Its fusion point is 1810°C; it is formed in normal clay refractories by heating at high temperature, or by prolonged heating above 1200°. Calcination at high temperatures of minerals such as sillimanite, andalusite, and cyanite results in a product containing 75 to 85% of mullite. Fused alumina is produced in a similar manner in an electric furnace. Silicon carbide has no melting or softening point; at 2250° it dissociates into the elements silicon and carbon. Between 1000 and 1200° it oxidizes fairly rapidly; above 1200° the result of this oxidation is the formation of a very viscous coating, which greatly retards further oxidation. The principal causes of failure in refractories are (1) plastic distortion, (2) permanent volume change (shrinkage or expansion), (3) spalling, and (4) chemical attack. Clay brick usually shrink during firing, the amount of shrinkage being in fairly good accord with the quantity of alumina present. High alumina brick must therefore be fired to a very high temperature. Silica brick exhibit a peculiar expansion behavior, which must be allowed for in the construction of a furnace. Silicon carbide may show a permanent expansion due to oxidation. Spalling of refractories arises from the nonuniform heating of the brick, one portion being caused to expand more than another. With regard to chemical attack, alkalis react readily with silica and alumina, and therefore have a serious effect on clay, fused alumina, and silicon carbide. Magnesia on the other hand, is resistant. Iron oxides will slag readily at high temperatures with fused alumina or silicon carbide, so that chrome, magnesia, or zirconia brick would give better service. Two further important factors are the structure of the refractory, and the physical and chemical characteristics of the product resulting from the reaction. Permanent volume change in service is reduced to a minimum by the use of "alundum" (fused alumina), "crystolon" (silicon carbide), or mullite, all these being the product of the electric furnace, and therefore completely pre-shrunk. In resistance to spalling, silicon carbide is at present superior to fused alumina and mullite. (*Trans. Ceram. Soc.* [Eng.])

Importance of testing refractories in construction of gas ovens. E. STEINHOFF. *Tonind.-Ztg.*, **51,** 919, 1009, 1047 (1927).—The demands made upon refractory brick in vertical chamber ovens are discussed in detail and the most important properties (1) thermal expansion, (2) constancy of volume, (3) resistance to load at high temperatures, and (4) thermal conductivity receive special attention. A new method of determining the linear thermal expansion is described. Two additional tests are outlined, which afford useful data on the quality of brick (1) the staining test (*Trans. Ceram. Soc.* [Eng.], **24,** 18A (1925)) and (2) the carbon monoxide and methane test. Both these gases may destroy refractories. The test is as follows: Carbon monoxide is passed through a number of flasks to remove moisture, oxygen, and carbon dioxide, and then through a refractory glass tube, which is heated in an electric furnace. An iron-constantan thermo-element having the junction in the center of the tube near the test piece is used to measure the temperature. A washing flask containing concentrated sulphuric acid, follows the furnace. Hints are given on the testing of mortars; much

greater expansion effects and volume fluctuation occur with high-silica than with high-alumina mortars. (*Trans. Ceram. Soc.* [Eng.])

Troubles of furnace builders with refractories. ANON. *Forging, Stamping, Heat Treating*, **13**, 231 (1927).—The conditions that exist in certain furnaces, particularly in underfired normalizing, enameling, and brass-melting furnaces, are considered, and the nature of the refractories which will meet these requirements is discussed. The two primary functions of refractories in all these furnaces are thermal insulation and conduction. Difficulties encountered in operating these three types of furnaces (fired with gas and oil) are outlined, and it is pointed out that the present requirements are: (1) A refractory material with considerable strength which will withstand temperatures of 1370 to 1425°C in an oxidizing atmosphere, and another which will prove satisfactory in a reducing atmosphere, these refractories to be used in constructing the piers of the furnace; (2) a material with high thermal conductivity to be used in the hearth, which will be resistant to oxidizing atmospheres. If a material cannot be found which is not harmed by metallic vapors such as are present in enameling furnaces, means must be found of protecting the refractory; (3) an insulating material must be found which will withstand temperatures of 1425 to 1485°, for the construction of doors and side walls. (*Trans. Ceram. Soc.* [Eng.])

Refractory materials for boilers and furnaces. F. HARTMANN. *Arch. f. Wärmewirt.*, **8**, 342 (1927).—The following points are dealt with: the standardization of tests; fusion process; mechanical strength at different temperatures; crushing strength; refractoriness under load; thermal conductivity; changes in apparent specific gravity in use; resistance to temperature changes; difficulties in choosing suitable brick for special purposes. (*Trans. Ceram. Soc.* [Eng.])

Refractory materials and their application to fuel economy. A. B. SEARLE. *Fuel Economist*, **3**, 461–63 (1928). (*J.I.S.I.*)

Expansion of fire brick when heated. A. B. SEARLE. *Fuel Economist*, **3**, 115–16 (1927).—Expansion curves of silica brick and other refractory materials are shown. (*J.I.S.I.*)

Dolomite bonding materials. O. KALLAUNER. *Stavivo*, p. 118 (1926).—Dolomite bonding materials may be classified as follows: (1) Dolomite bonding materials, the chief bonding component of which is MgO; (2) dolomite lime, composed of CaO and MgO; (3) mixed dolomite lime resembling hydraulic limes; (4) dolomite cement, containing 25% and more of $SiO_2 + Al_2O_3$. When standard dolomite is heated to a high temperature, CO_2 begins to separate at 500°C, the separation becomes quicker at 650°C, and at 710 to 730°C almost all the CO_2 which was bound to the magnesium separates at once. CO_2 combined with calcium begins to separate at 870°C, and the separation becomes more active at 900°C. (*Trans. Ceram. Soc.* [Eng.])

Silica brick plant. ANON. *Ceram. Ind.*, **13** [1], 66–70 (1929).—A description of the plant of E. J. Lavino Co. F.P.H.

Bonus systems. ANON. *Brick Clay Rec.*, **75** [2], 80–85 (1929).—The quality of the products of the E. J. Lavino & Co. is kept up by the working out of bonus systems for the fabrication crews and also for the firemen. The equipment and methods used in this plant are described in detail, as are the two bonus systems. E.J.V.

Dumortierite. S. F. GLINKA. *Min. Resources and Tech.* [Moscow], No. 3, 189–91 (1927). (*C.A.*)

National Physical Laboratory progress. JOSEPH PETAVEL. *Chem. & Ind.*, **48**, 657–58 (1929).—Crucibles of special refractory materials capable of withstanding very high temperatures and the strong chemical action of the molten alloys have been necessitated by the production of new alloys containing Ni, Cr, Fe, C, and Si, designed for use at very high temperatures in modern internal combustion engines and turbines.

Ordinary steel is quite soft long before such temperatures are attained. A hydraulic extrusion machine has been designed for the manufacture of the new refractories. A glass and silica apparatus permitting the quick accurate determination of hydrogen in iron alloys has been designed. H.H.S.

Manufacture of clinkers in Holland. E. Buch. *Süddeut. Tonind.*, **11**, 5 (1929).—An illustrated account is given of the method of manufacture. (*Trans. Ceram. Soc.* [Eng.])

Chrome mining in New Caledonia. Quincy F. Roberts. *Commerce Repts.*, **25**, 781 (1929).—The two largest sources of chrome ore are Southern Rhodesia and British India. Complete statistics for 1926 show that New Caledonia furnished about 18% of the crude chromite produced, with Rhodesia producing more than India and New Caledonia combined. As the old methods of mining cannot be used at Tiebaghi and the new methods add to the mining costs, the expense of production is very high. E.J.V.

Magnesite deposits of Spain. K. A. Redlich. *Zeit. prakt. Geol.*, **35**, 117 (1927).—The dense magnesites of Almeria, south of Sierra Nevada, and the coarse-crystalline magnesite from near Reinosa, N. Spain, their geological positions, petrographic structure, etc., are discussed. Both kinds are used in the making of refractories. (*Trans. Ceram. Soc.* [Eng.])

BOOKS

Bauxite. Anon. *Quarry*, **32**, 359 (1927).—A review of the book, Bauxite, by C. S. Fox, which deals in detail with the origin, constitution, known occurrences, and commercial uses of bauxite. (*Trans. Ceram. Soc.* [Eng.])

Dolomites of South Tyrol. W. Salomon-Calvi. *Nature*, **121**, 83 (1928).—A review of the work: "Das Grödener-, Fasse-, und Enneberggebiet in den Südtiroler Dolomiten: Geologische Beschreibung mit besonderer Berücksichtigung der Überschiebungserscheinungen," by M. M. Ogilvie Gordon. 1 und 2 Teil: Stratigraphie-Tektonik; 3 Teil: Paläontologie. (*Trans. Ceram. Soc.* [Eng.])

PATENTS

Furnace walls. Babcock & Wilcox, Ltd. Brit. 310,444, June 19, 1929. A hollow furnace wall through which air may be passed for cooling purposes comprises an inner refractory wall, with one or more courses of recessed bricks securing hooked members and vertical I-beams in contact with the wall and forming vertical air ducts which are enclosed by an outer casing.

Furnace. David S. Jacobus and Nathan E. Lewis. U. S. 1,719,475, July 2, 1929. In a furnace wall, a refractory wall comprising a plurality of tile placed edge to edge with the edges spaced, means supporting each tile so that each tile is permitted to expand without contacting with an adjacent tile, a substantially air-tight metallic lining over the exterior of the refractory wall, and a casing spaced from the lining and forming an air passage between the lining and the casing.

Crucible. Gaylord H. Halvorson. U. S. 1,720,327, July 9, 1929. In a device of the character described, the combination of a silica receptacle, means in the receptacle comprising lugs for positioning a silica crucible in the receptacle whereby the crucible is spaced from the bottom and walls of the receptacle, and silica tops for the receptacle and crucible.

Forming articles of clear vitreous silica. B. F. Niedergesass. Brit. 296,059, Aug. 24, 1927. Heated silica particles are projected onto a support which is heated to a temperature approximately the melting point of silica so that the particles coalesce and become incorporated with the support. An example is given of the formation of an astronomical mirror by deposition of clear vitreous silica on a foundation plate of opaque silica. An apparatus is described. (*C.A.*)

Refractory substances. T. R. HAGLUND. Brit. 302,087, Feb. 18, 1928; Fr. 650,883, March 15, 1928. In the reduction of oxides or ores in an electric furnace for the production of iron and other metals and alloys such as ferro-chrome, the charge is so constituted by the addition of slag-forming materials such as magnesite and bauxite that a highly refractory slag is obtained containing less than 15% SiO_2, 15% MgO, 20% Al_2O_3, and up to 35% Cr_2O_3. The slag may be cast or mixed with binders. (*Trans. Ceram. Soc.* [Eng.])

Linings for rotary kilns. G. POLYSIUS. Fr. 618,089, June 24, 1926. Highly refractory materials, such as corundum, zirconium, etc., are mixed with *ciment fondu* and water; blocks, etc., formed from the mixture are allowed to set. (*Trans. Ceram. Soc.* [Eng.])

Terra Cotta

Deformation study of cobalt oxide-alumina-silica mixtures. THOMAS M. FELTON. *Jour. Amer. Ceram. Soc.*, **12** [8], 548–51 (1929).—A deformation study of CoO–Al_2O_3–SiO_2 mixtures was made to determine the fluxing effect of cobalt in such silicate mixtures as glazes and enamels. The deformation eutectics for cobalt and alumina, cobalt and silica, and cobalt–alumina–silica were determined and isothermal diagrams drawn.

New glaze technique. ERNST BUSS AND KARL BLUM. *Tonind.-Ztg.*, **52** [74], 1491–92 (1928).—The rediscovery of terra sigillata is discussed. F.P.H.

Kiso-stone as a raw material of pottery. JIROKICHI KUMAZAWA. *Jour. Jap. Ceram. Assn.*, **36** [431], 552–54 (1928).—Kiso-stone was discovered by Seiichi Maruyama in a mountain near Niegawa Station several years ago. It is a liparite rich in iron. If cut, it looks like a well-grained wood. Its plates are used raw or fired to about 1100°C. The analysis is as follows:

Ignition loss	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	MnO	Alkalis	Total
4.25	72.28	15.18	1.30	0.37	0.39	0.06	5.62	100.45

Wasted pieces produced in making plates are utilized by manufacturers of terra cotta and tile. Bodies composed of Kiso-stone 55 to 65, Kibushi clay of Seto 20 to 30 and feldspar of Yodo, Tokigun, 15, with an ordinary raw glaze, fired at cone 6a, have given satisfactory results. They are cream-colored and suitable for the manufacture of terra cotta, tile, sanitary ware, etc. S.K.

Manufacture of stoneware. W. SCHUEN. *Tonind. Ztg.*, **52** [80], 1604–1608 (1928).—An abstract of a book by S. on the manufacture of stoneware. The following subjects are discussed: (1) manufacture of sewer pipe, (2) preparation of clays, (3) mixing of clay and grog, and (4) auger machines and presses. F.P.H.

Don Manuel Tolsá. A. ESCONTRIA. *Rev. Mex. de Ing. y Arquit.*, **7** [5], 159–209.—Art and architecture of Mexico cannot be discussed without mentioning the great Spanish architect Tolsá of the second part of the 18th Century. He was the originator of a ceramic class in the Akademy of San Carlos, and made, as well as used, colorful ceramic tile for floors and walls. His kilns were of his own design. T.W.G.

White Wares

Further developments on torsional apparatus for measuring plasticity. C. W. PARMELEE AND R. D. RUDD. *Jour. Amer. Ceram. Soc.*, **12** [8], 552–55 (1929).—A critical study of the apparatus has been carried on to reduce variations in results due to manipulation. Specimens were made by squeeze molding in saturated plaster molds instead of forming in the hands. The loading device was changed so that the stress could be increased continuously instead of intermittently as heretofore. The speci-

mens were designed so that the ratio of the maximum stress in the outer fibers of the circular section was to that of the square section as 3.8 is to 1. Clays having the same water content were compared by studying the slopes of the stress-strain curves up to the proportional limit.

Mechanical glazing of porcelain ware and earthenware. A. GRIGORJEW. *Ceramics and Glass* [U.S.S.R.], **2**, 39–40 (1929).—A brief description and schematic design of the apparatus for mechanical glazing of pottery invented by A. I. Fedoroff is given. The efficiency of one regular working day (8 hrs.), with the use of one H.P. motor, has reached 38,000 pieces of pottery. A table is given showing in detail the cost of glazing by hand and by the new mechanical process. Cost of mechanical glazing of 1000 pieces of pottery amounts to 28.9 kopecks (about 14¢), as compared with 89.9 kopecks (44¢) for glazing by the usual hand methods. The quality of the glazing fully met the required conditions. Without any consideration of accidents by hand work, the cost of glazing is reduced 300%. G. sums up the advantages of Federoff's apparatus as: (1) increased efficiency, (2) lowered costs, (3) qualified glaziers unnecessary, (4) burns and poisoning avoided, (5) easier manufacturing, (6) space saved, and (7) use of the commercial muriatic acid instead of nitric acid and C.P. muriatic acid is possible.

W.A.

Staple porcelain (all clay) plumbing fixtures. ANON. Bur. Stand., *Commercial Standard*, CS4–29.—This *Commercial Standard* covers grading rules, nomenclature, definitions, dimensional standards, including roughing-in measurements, standard types and sizes of porcelain lavatories, bath tubs, laundry trays, kitchen sinks, shower receptors, slop sinks, and stall urinals. It should prove of material interest to every architect, plumber, master plumber, plumbing jobber, and user who is interested in obtaining maximum quality of this ware as well as standard types which are easily matched or replaced when required. R.A.H.

Improved chinaware-testing machine. ANON. Bur. Stand., *Tech. News Bull.*, No. 146, pp. 56–57 (1929).—A modified impact machine for chinaware has been designed and built at the Bureau to obviate certain difficulties encountered in the use of a similar testing machine specified in the U. S. Govt. Master Specif. for Vitrified Chinaware, No. 243A. The modified testing machine, as was specified is a pendulum apparatus, having one steel cylindrical hammer weighing 5 ounces and suspended by 8 piano steel wires. Because of its manner of suspension this pendulum swings in a vertical plane in an arc having a 24-inch radius, thus eliminating one of the objectionable features of the original machine. The modified machine has the advantage of using only a single hammer instead of several of different weights used with the specified machine as well as only a single scale instead of two as with the older machine. Comparative testing of the old and new machines on 33 brands of chinaware show that there is practically no difference in results. R.A.H.

Influence of liquefying agents for cast bodies on casting rate of kaolin and clay suspensions in plaster molds. R. RIEKE AND K. BLICKE. *Ber. deut. keram. Ges.*, **10** [2], 73–94 (1929).—The casting rate of slips, *i.e.*, the time required for the formation of a body of definite thickness on the mold is influenced by various factors, such as (1) the porosity of the plaster mold, (2) the water content of the body, (3) the kind and size of particles of the materials composing the body, (4) the presence of soluble constituents in the raw materials, and (5) the kind and amount of liquefying agents (dope) added. The work reported deals mostly with the effect of the addition of various amounts of sodium carbonate, sodium hydroxide, or sodium silicate solutions on the casting rate of various clay slips. The effect of the following variables on the casting rate was investigated, (1) kind of raw materials, (2) water content of slip, (3) pouring time, (4) amount of electrolyte added, (5) kind of electrolyte. F.P.H.

Ceramic magnesium silicate. II. Vitrification behavior and constitution of ceramic bodies. OTTO KRAUSE. *Ber. deut. keram. Ges.*, **10** [2], 94–104 (1929).—The effect of the firing temperature on the following properties of a steatite body was investigated: (1) solubility of MgO, (2) solubility of SiO_2, (3) shrinkage, (4) specific gravity, (5) absorption, and (6) compressive strength. The solubility experiments indicate a marked change taking place in the body in the region from 800 to 900°C. The specific gravity of the body reaches 2.9 when fired to 1100°C and 2.93 when fired to 1400°C. The shrinkage increases until the firing temperature of 1350° is reached after which the body begins to expand. X-ray investigations of the changes taking place in the talc body when fired to various temperatures indicate that at 900°C the clino-enstatite lines begin to appear and that at 1100°C lines similar to cristobalite lines make their appearance. The thermal expansion curve for the steatite body is given covering the range from 20 to 600°C. The vitrification of steatite bodies is explained with the aid of the temperature-composition diagrams of the MgO–Al_2O_3–SiO_2 system, and the MgO–SiO_2 system. F.P.H.

Causes of cracking in pressed porcelain bodies. C. DORNEDDEN. *Sprechsaal*, **62** [23], 409–13 (1929).—The most frequent faults encountered in the pressing of dry-press porcelain bodies are cracks in the body, of which the following causes are fully discussed and illustrated: (1) improper clay constitution; (2) dies; (3) wrong press principle; (4) wrong operation of the press; (5) faulty design of the porcelain body. T.W.G.

Influence of glaze on insulator strength. D. H. ROWLAND. *Gen. Elec. Rev.*, **32**, 136–38 (1929).—Test data are given showing the tremendous effect of surface conditions on mechanical strength of porcelain. It is possible to increase or decrease strength of porcelain by glazing. Glaze and porcelain must be balanced to avoid tension. (*C.A.*)

White stoneware and other white ceramic masses. I, II. FÉLIX SINGER. *Chem. Ztg.*, **53**, 105–106, 126–29 (1929).—Stoneware and porcelains are compared as to composition, methods of manufacture, microstructure, and general properties and uses. (*C.A.*)

Effect of sulphur compounds in glazes. ANON. *Süddeut. Tonind.*, **11**, 24 (1929).—A brief résumé is given. (*Trans. Ceram. Soc.* [Eng.])

Porcelain formation process. I. F. PONOMAREFF. *Keram. i Steklo*, **5**, 17 (1929).—The reactions taking place in simple mixtures of kaolin and feldspar, feldspar and quartz, feldspar and alumina, etc., were studied. In a porcelain body, the glassy phase richest in silica and alumina approaches in composition the formula: K_2O 1.15, Al_2O_3, $12SiO_2$. The "skeleton" of porcelain is formed by the kaolin, which remains unchanged in the body. The grains of kaolin are surrounded by layers varying in chemical composition between Al_2O_3, $2SiO_2$ and K_2O, Al_2O_3, $6SiO_2$. The quartz grains also react with the feldspar. The rest of the porcelain body consists of fused feldspar, at many points saturated with quartz, at others with kaolin. Quartz and kaolin are in the solid state at kiln temperatures, so that reaction between them is impossible. (*Trans. Ceram. Soc.* [Eng.])

Glassware and china for cooking. ANNE PHILLIPS. *Amer. Home*, **2** [5], 582 (1929).—Cooking glass and cooking china appear in many forms and all of them are suited to the dining room as well as to the oven or the refrigerator. The new platters, grill plates, and decorative dishes for use in the oven are discussed. E.J.V.

Colloidal content of china clays. ANON. *Jour. Frank. Inst.*, **207**, 262 (1929).—See *Ceram. Abs.*, **8** [4], 29 (1929).

Modernizing an old Hanley pottery. ANON. *Pottery Gaz.*, **54** [625], 1112–13 (1929).—The old Britannic Pottery was one of the oldest of the Hanley potteries.

It had an old-fashioned layout which wasted too much time between the different stages of production. The plant was bought by Bakewell Bros., Ltd., who have taken the shell of the old factory and fitted it with an entirely new mechanism and built new bisque and glost warehouses, a printing shop, and a model dipping house.

E.J.V.

BOOKS

Fabrication de la porcelaine. II. Cuisson et décoration. Coll. grandes encyclopédies industrielles. MARC LARCHEVÊQUE. J.-B. Ballière et Fils, Paris. 370 pp. F. 70. (*C.A.*)

Elementi di tecnologia ceramica. I. Tecnologia ceramica generale. II. Tecnologia speciale; fabricazione dei vari prodotti ceramici. 48 pp. **III. Tecnologia del controllo di fabricazione, dei rivestimenti, e della decorazione ceramica.** MAURIZIO KORACH. 83 pp. Museo della ceramiche Faenza. (*C.A.*)

PATENTS

Forming ceramic tile, plates, etc. JULIUS LAMPFERHOFF. U. S. 1,719,772, July 2, 1929. The process of forming ceramic tile, plates, etc., comprising spreading a facing layer upon a supporting surface, placing a mold frame having its lower side formed with knife edges upon the surface layer, causing the frame to penetrate through the surface layer to the support, filling the frame with the backing material, settling the backing material without disturbing the facing layer by shaking the support unitarily with the mold frame, removing the mold frame when the molded articles are only partly dried, and drying them completely subsequent to the removal of the molding frame.

Insulator. GEORGE HENRY SCHOENTHALER. U. S. 1,719,945, July 9, 1929. In an insulator, a dielectric body having a stem portion formed at its underside with a recess and an undercut groove within the recess, a pin extending within the recess and including a pair of leg portions each split in sections with the sections spaced apart, a wedge member located within the recess and engaging against the sections of both legs of the pin for expanding the pin into the groove, and means for embedding the pin within the recess.

Assembling insulators. STEWART L. MOORE, JR. U. S. 1,719,989, July 9, 1929. The method of cementing together the parts of an insulator, consisting in subjecting the insulator to rapid vibration and to pressure while the cement is poured therein.

Glazes for electric insulators. J. E. POLLAK. Brit. 309,426, June 6, 1929. In order to increase the strength of insulators made of ceramic material, the parts of the insulator body which are engaged by pins, caps, or other parts that transmit stresses are coated with a glaze of high tensile, compressive, or bending strength. The body of a suspension insulator, *e.g.*, may be given coatings of the glaze on those surfaces which are acted on by tensile or compressive stresses. A suitable glaze for the purpose may consist of silica, 73.1%; alumina, 21.5%; magnesia, 0.4%; lime, 2.7%; and soda, 2.3%. The effect of the glaze is improved if it is made resistant to abrupt changes of temperature.

Pottery making. W. J. MILLER. Brit. 309,491, June 6, 1929. A portable tray for use in the manufacture of pottery comprises a frame formed with seats for accommodating molds, etc., and of such construction to permit of access to the molds, etc., from beneath the tray.

Electric insulators. J. E. POLLAK. Brit. 309,884, June 12, 1929. A lead-in insulator of the condenser type has a ceramic dielectric with coatings of an electrically-conducting ceramic material which is fired at the same time as the ceramic dielectric. The ceramic coatings may also be of nonconducting material which has a dielectric constant differing from that of the dielectric proper.

Electric insulators. BROWN, BOVERI, ET CIE, A.-G. Brit. 310,021, June 12. 1929. In suspension and supporting insulators of the type comprising a bar, the screens of metal or porcelain usually provided for protection against rain or snow, are further formed with an annular flange forming with the body of the insulator a cavity, the function of which is to prevent the deposition of conductive materials such as salt, when the insulators are used in coastal districts. One or more of the flanged screens may be used and may be formed so that the space is cylindrical, conical, spherical or other shape.

Electric insulators. C. H. THOMPSON. Brit. 310,201, June 12, 1929. Porcelain insulators having a number of parts cemented together have the junction faces of the parts, prior to assembly, coated with a film of celluloid or other cellulosic compound applied as a solution in a volatile solvent and allowed to dry. The insulator may comprise a metal spindle on which are mounted three porcelain sheds and a metal cap held together by cement. The faces of the porcelain parts in contact with the cement are unglazed and the cemented faces of the spindle and cap are serrated or grooved. The faces both of the porcelain and metal which will contact with the cement are coated with cellulosic solution.

Electric insulators. PORZELLANFABRIK P. ROSENTHAL & CO., A.-G., AND W. SCHMIDT. Brit. 310,222, June 12, 1929. In an insulator of the type in which the cap or pin of the insulator is secured to the body part by means of a metal filling, a colloidal casting, such as a suspension of alumina in water, is applied to the insulator body before the molten metal is poured in, so as to avoid stresses in the insulator body due to the shrinkage of the metal filling when cool. When the molten metal is applied, the alumina suspension gives off water, decreasing in volume, and owing to its elasticity, allows the filling to shrink without strain. In a modified construction, a layer of soft metal may be applied to the body part by spraying. If the soft metal is of higher melting point than the filling, it will act as a cushion; if of lower melting point, it will melt during the cooling of the filling and thus make room for shrinkage of the filling. In the embodiment, a layer of the alumina suspension is applied to the head of an insulator body and the cap placed in position. The insulator is then inverted and lead alloy poured into the space between the cap and the insulator.

Pottery. W. J. MILLER. Brit. 310,961, June 26, 1929. Clay is forced, under pressure, into a closed space formed between a mold and an upper die or mold-receiving member, the walls of which are adapted to control the adhesion of the material. Molds supported on a chain conveyer are raised to coöperate with an upper die and are charged with material by a plunger working in a chamber extending from an extrusion chamber. The plunger is carried by a hollow rod having a fluid connection and reciprocated by a cam and lever. The die is lined with plaster and is furnished with a fluid connection. The mold is supported by a telescopic hollow stem, also having a fluid connection which is reciprocated by a cam and lever. Rotation may be imparted to the mold through friction gearing, controlled by a cam-operated brake. The adhesion of the material is controlled by applying vacuum or pressure with or without moistening fluid, the fluid supply being controlled by a cam-actuated valve. The mold may be associated with a magnetic chuck and the upper die may be furnished with an electrical heating device, the appropriate connections being made by rings on the stem and contacts.

Equipment and Apparatus

Batch classification in the laboratory. A. W. FAHRENWALD AND CLARENCE THOM. Bur. Mines, *Repts. of Invest.*, Serial No. 2924, 5 pp. (1929).—A description and picture is given of a batch laboratory classifier for use in conjunction with other batch laboratory

apparatus such as batch ball mills, flotation machines, and tables. One application of the apparatus is given. The batch classifier is closed with the batch laboratory ball mill just as classifiers are closed with ball mills in practice. Preliminary data from one such series of cyclic tests give some insight into the relation of power consumption and fineness of grinding in closed-circuit operations. Locked laboratory closed circuit tests of this kind are probably more efficient than is the same operation in practice because of the greater efficiency obtained in the laboratory apparatus. In preparing samples for laboratory flotation tests, this procedure is to be recommended over the usual method of putting the charge in a mill and regulating the grinding time to give the "mesh through" product. R.A.H.

Empirical formulas for platinum: 90% platinum + 10% rhodium thermal. MOTOTARO MATSUI. *Jour. Soc. Chem. Ind.* [Japan], **32** [1], 33–36 (1929).—Seven types of interpolation formulas for the thermals and convenient methods of computation described in several publications are discussed. For the temperature range 300 to 1200°C, M. recommends the expressions (3) $e = -a + bt + ct^2$ and (7) $e = a + bt + ct^2 + dt^3$ as best and the expression (4) $t = a + be - ce^2$ as convenient to calculate the temperature from the e.m.f. measured (e = e.m.f. in μv and t = temp. in °C). For Pt – 90% Pt + 10% Rh thermal of the first quality, the constants a, b, and c in the formula (3) as well as (4) might be always considered to give similar values. S.K.

Measurement of electromotive force of thermal at freezing point of the standard pyrometric samples. MOTOTARO MATSUI AND SEIZO OKA. *Jour. Soc. Chem. Ind.* [Japan], **32** [1], 38–43 (1929).—Experiments on the measurement of e.m.f. of Pt: 90% Pt + 10% Rh thermals, supplied from Siemens-Halske and Leeds & Northrup, at the freezing points of the standard pyrometric samples certified by the Bureau of Standards have been made. The freezing points of pure metals of the different origins were computed by the empirical formulas and compared to those fixed by P. T. R., 1924. S.K.

Chromium plating. ANON. *Can. Chem. Met.*, **13** [6], 30 (1929); reprinted from *Technical Topics*.—The advantages of chromium plating are its great resistance to atmospheric corrosion, resistance to oxidation, and hardness. It is also unattacked by salt water or corrosive chemicals such as ammonia, nitric acid, and hydrogen sulphide. Many other important uses for chromium plating are being developed. It has been employed in the facing of gramaphone record matrices, steel-plug gages, and printing plates with great success. Rolls used in paper finishing, glass manufacture, and production of rubber articles, have a longer life when chromium plated. Chromium-plated molds in glass-bottle plants, for the manufacture of the many articles now made of the various synthetic resins, and for certain types of metal molding have proved equally serviceable. Chromium plating is not without its difficulties, but through research, many of them have been successfully overcome. E.J.V.

Clay gas vents. ANON. *Brick Clay Rec.*, **75** [1], 27 (1929).—Gas vents frequently receive waste gases at temperatures as high as 800 or 900° for limited periods of time. The products of combustion of gases, moisture, carbon monoxide, sulphur (sulphuric acid), etc., must be resisted by the successful vent pipe. Tests in which the most extreme conditions to which vent pipe is subjected in practice were put into effect showed that fireclay vents were the best to use. Records show no fires due to the failure of fireclay vents. E.J.V.

Rustless steel for glass cutting. ANON. *Popular Sci.*, **115** [2], 63 (1929).—Steel so hard it scratches glass like a diamond, does not rust and retains its hardness even when red-hot, is now being produced in America by a nitrating process. When an inexpensive form of steel is treated in a hardening box with circulating ammonia gas heated to a high temperature, it develops the thin, hard, rustproof skin distinguishing

the new metal. Nitrated steel pins and bushings functioned some 22,000,000 times with no signs of wearing. E.J.V.

Wider belts and pulleys for line start motors. J. R. HOPKINS. *Brick Clay Rec.*, **75** [2], 92–93 (1929).—For the line start motor a belt should be 50% wider than for the old type of the same power. E.J.V.

Automatic cutting tables. ANON. *Brit. Clayworker*, **37** [438], 263–64 (1928); **38** [442], 423 (1929).—Continuation of previous articles describing (1) Chambers side cutting, (2) Keller full automatic, (3) Anderson (Sweden), (4) Frey (Switzerland), (5) Fate-Root-Heath, (6) Freese auto, (7) Bonnot rotary, (8) Riddell rotary, (9) Steele and Sons, and (10) Brewer. See *Ceram. Abs.*, **8** [4], 271 (1929). R.A.H.

Pressure measurements in fan testing; suggested nomenclature. WALTER S. WEEKS. *Min. and Met.*, **10** [271], 326–28 (1929).—Confusion appears in discussions of fan testing because of disagreement on what energy should be credited to the fan and because terms used have double meanings. W. discusses useful energy credited to the fan, methods of determining this energy, and suggests changes in nomenclature. F.P.H.

Cement slurry filter. ANON. *Rock Prod.*, **32** [12], 116–17 (1929).—An automatic filter for dewatering of cement slurry in wet-process mills is described. The filter is of the vacuum drum type; filter cake is removed from the drum by a canvas compress belt driven by contact with the cake as the drum rotates. F.P.H.

Cement mill grinding. TH. TRAMPE. *Rock Prod.*, **32** [12], 58–59 (1929). F.P.H.

Evaluating crushing efficiency. WILL H. COGHILL. *Rock Prod.*, **32** [12], 59–60 (1929). F.P.H.

Drying coal. ANON. *Rock Prod.*, **32** [12], 113–14 (1929).—An entirely new form of drier has been recently designed utilizing the waste heat which is radiated from the outer shell of a rotary kiln. By utilizing this heat, coal used for firing can be dried by the kiln itself. The equipment also can be used for drying shale or limestone in dry-process cement plants, or it may be adapted to any drying problem where a rotary kiln or cooler is used in the process. F.P.H.

Open and sealed pores in ceramic products. W. MIEHR, H. IMMKE, AND J. KRATZERT. *Tonind.-Ztg.*, **52** [78], 1566–68 (1928).—A new type of apparatus similar to that developed by Pressler (*Jour. Amer. Ceram. Soc.*, **7** [3], 154–59; [6], 447–51 (1924)) is described and the results obtained with their apparatus on a great number of refractory products are compared with those obtained with the pycnometer method. It is concluded that the ordinary refractory products contain a very small number of closed pores. F.P.H.

Elutriation apparatus. V. BUSCH. *Tonind.-Ztg.*, **52** [76], 1527–29 (1928).—A type of elutriator is described in which the first tank is provided with an agitator located in the bottom of the tank to prevent the flocculation of material in the tank where the concentration of solids is the greatest. F.P.H.

Two new laboratory rotary kilns. FR. HEINRICH. *Chem. Fabr.*, **15**, 173–74 (1929).—The kilns are fired with gas and both are illustrated and described. T.W.G.

New speed drier for chemical industry. OTTO WOLFF. *Chem. Fabr.*, **16**, 181–82 (1929).—A room drier with recirculation by fan is described and illustrated, being similar to some of our types of driers. T.W.G.

Whirlwind pulverizer. ANON. *Cement, Mill & Quarry*, **34** [7], 66 (1929).—An improved impact-attrition pulverizer has been operating on many different materials with success. Ores, limestones, hydrated lime, coal, coke, etc., are reduced to a uniform fineness in many cases without the need of air separation. E.P.R.

Adapting machines to new cutting alloys. E. F. DuBrul. *Abrasive Ind.*, **10** [7], 18 (1929).—Discovery and promotion of the new cutting alloys composed of tungsten-carbide and other similar materials is bound to have great influence on machine tool design. With these tools any machine now employed at less than its full capacity can be utilized to a greater extent than at present. With tungsten-carbide tools they can be run faster which will reduce the necessity of buying new tools, thus increasing the capacity of the shop. E.P.R.

Tungsten-carbide as cutting material. Frank C. Spencer. *Abrasive Ind.*, **10** [7], 23–24 (1929).—At the present time there are two tungsten-carbide products available in the U. S., Carboloy, manufactured and sold by the Carboloy Co., N. Y., and Widia, manufactured by the Krupp Co., Essen, Germany, and imported by Thomas Prosser & Sons, N. Y. In addition to Carboloy two other brands will be manufactured in the U. S., Strauss metal and diamondite. Strauss metal will be a product of the Ludlum Steel Co., while diamondite will be manufactured by the Firth-Sterling Co. This brand has not yet appeared on the market although an extensive development program is being carried on. The article is an abstract from a paper presented at the A.S.M.E. meeting in Rochester, May, 1929. E.P.R.

Electric motor drives for types E and K stokers. Anon. *Cement, Mill & Quarry*, **34** [7], 63 (1929).—An electric motor drive has been developed which is applicable to stokers. E.P.R.

Light mechanical transport in brickyards. Anon. *Brit. Clayworker*, **37**, 345 (1928).—Five kinds of trucks are illustrated and described.
(*Trans. Ceram. Soc.* [Eng.])

A precision pipette viscometer. S. W. Ferris. *Ind. Eng. Chem.*, **20**, 974 (1928); *Analyst*, **53**, 675 (1928).—A viscometer made entirely of glass is described. When determining viscosities at 100°F the jacket is filled with water; for determinations at 210°F steam at normal pressure is passed through the jacket. The pipette has a capacity of about 5 cc. and the orifice is about 0.5 mm.
(*Trans. Ceram. Soc.* [Eng.])

Gas testing. A. Sander. *Z. Ver. deut. Ing.*, **73**, 531–38 (1929).—Descriptions of apparatus for gas testing, methods of use and calculations involved, are given in full. Included are the Junker gas calorimeter (old and new types), Graefe, Dommer, and Strache-Löffler calorimeters, and the recording calorimeter "Union" (likewise designed by Dommer); specific gravity apparatus of the Bunsen-Schilling, Zipperer, Simmance and Abady, "Union" types; pressure meters; gas analysis apparatus such as Brüggemann's, the Gasinstitut Karlsruhe, etc.; Raupp apparatus for H_2S determination; Kattwinkel apparatus for determining C_6H_6 in gas; methods for determination of total S, NH_3, etc. Post-war economic conditions have made it imperative that closer control of gas quality be maintained than was the case earlier than 1918. (*C.A.*)

Drying bricks in three hours. Anon. *Brick Clay Rec.*, **73**, 432 (1928).—A five-tunnel drier, 85 ft. long, is described, in which 45,000 bricks are dried in 8 to 9 hrs.
(*Trans. Ceram. Soc.* [Eng.])

BOOKS

Excavating for Profit. Sauerman Bros., Inc., Chicago. 56 pp.; reviewed in *Cement, Mill & Quarry*, **34** [7], 64 (1929).—Design, construction, principles of operation, and the varied uses of the Sauerman slackline cableway excavators in excavating and rehandling earth materials are discussed. E.P.R.

Treatise on Chemical Engineering. Godfrey Martin. Crosby, Lockwood, and Sons, London; reviewed in *Rock Prod.*, **32** [12], 93 (1929).—A full discussion of the laws of gas flow is given and illustrations and practical examples of how to apply these laws to the various engineering problems connected with the cement industry are included.

The tables given are unique and elaborate and it is claimed that the data collected in this volume are the most complete on the subject published in any language. A considerable amount of material is given on the subject of dust settlement in industrial operations, the separation of materials of different size or of different shape and specific gravity, and the pneumatic transporting of granular material. The 31 chapters of the book are well illustrated. F.P.H.

Kilns, Furnaces, Fuels, and Combustion

Muffle test kiln. F. W. HORST. *Chem. Fabr.*, **23**, 280–81 (1929).—The kiln described and illustrated is fired with gas from below, has a combustion chamber below the crucible and a refractory bell above it, all surrounded by refractory blocks. The kiln is mounted on a steel tripod. T.W.G.

Flat arch for kilns. ANON. *Brit. Clayworker*, **38** [446], 84–86 (1929).—The patent of a French engineer, M. A. C. Ragoucy, is described in *Brit. Clayworker* (see *Ceram. Abs.*, **7** [2], 97 (1928)). Photographs show details of construction. In addition to the advantages listed in the earlier article the following are given: (1) increase of capacity of a kiln of given width of chamber; (2) improved distribution of the hot gases and flames among the goods; (3) great reduction in cost both of original construction and maintenance; (4) ease and rapidity of replacement of any fire blocks which may become damaged; (5) adaptability to all types of kilns. R.A.H.

Placing the kiln chimney. ANON. *Brit. Clayworker*, **38** [446], 91 (1929).—The earliest continuous kilns designed by Hoffman were all circular in plan and the obvious position for the chimney was in the middle of the structure. With the advent of the oblong continuous kiln the possibility of an external chimney was manifest, but opinion is still divided as to whether the "central" or "external" position is preferable. An external chimney has the advantage of enabling the building of a much narrower kiln and so reduces the cost of construction of the kiln, although this is partly offset due to the necessity of having a taller chimney in order to create the proper draft. To obtain a good draft the height of a central chimney should be at least one-half the tunnel length of the kiln. If an external chimney is used then its height should be about 50% greater. The cost of working a kiln with an external chimney is greater as the gases must be drawn from the kiln at a greater temperature. When all data are considered a central chimney is preferable. R.A.H.

Setting tile in kiln through crown. ANON. *Brick Clay Rec.*, **75** [1], 29 (1929).—By taking large sized tile into the kiln through a hole in the crown three hours of setting time are eliminated, as also is the hard work required in lifting the heavy pieces and tossing up the lighter ones. The brick are relaid in the crown opening in an hour. E.J.V.

Tunnel kiln for firing tile. ANON. *Ceram. Ind.*, **13** [1], 48–52 (1928).—The glost kilns (Flint Faience and Tile Co.), employ a water-cooling system for a part of their operation. These kilns are 150 ft. long, the car schedule is about 15 to 20 min. and from 7 to 9 hours in the kiln. These kilns will fire to cone 11. Each car holds about 20 sq. ft. of tile laid one high. The water-cooling system consists of a series of coils on the sides and top of the kiln near the cool end. F.P.H.

New arch construction for ceramic kilns and industrial furnaces. HARRAENS. *Tonind.-Ztg.*, **52** [87], 1731–32 (1928). F.P.H.

Design of generators and generator reactions. E. TERRES. *Gas Wasserfach*, **71**, 1205–13 (1928); *Gas Age-Rec.*, **63** [23], 791 (1929).—A study was made of the relation existing between the reactions that take place within the gas generator and the flow of gas therein, and their effect upon the design and construction of the generator. It was established at the outset that the proportion of hydrogen contained in the gas

made is of greater importance from the standpoint of the efficiency of the generator than the proportion of carbon dioxide, which has been used as a criterion. Another interesting point developed was that the fuel bed should be considered to be divided up into vertical and not horizontal layers as far as the composition of the gas made is concerned. Numerous tests were thus conducted on gas obtained from various parts of the fuel bed. The various reactions that take place within the generator are to be considered as taking place within zones which extend up to the surface of the fuel. Gas taken from the central zone was found to be of good composition, but the percentage of carbon dioxide in the gas was found to increase as the zone neared the walls of the generator. F.P.H.

Use of tunnel kiln in brick industry. A. POPOFF. *Ziegelwelt*, **58**, 597 (1927).—The annular kiln and the tunnel kiln are compared. For a daily production of 20,000 bricks, the total cost of a tunnel-oven plant is less than that of annular kilns, and for greater productions than this the relation becomes more favorable to the tunnel kiln. (*Trans. Ceram. Soc.* [Eng.])

Heat concentration in industrial furnaces. W. SCHUEN. *Tonind.-Ztg.*, **52** [74], 1495–96 (1928).—A table showing the energy concentration per unit time in various types of industrial furnaces is presented and discussed. F.P.H.

Chemical processes in the gasification of brown coal. H. KNOPF. *Gas Wasserfach*, **71**, 1218–21 (1928); *Gas Age-Rec.*, **63** [25], 868 (1929).—Measurements of temperature and of gas composition have been made at points in the axis of the fuel bed of a Heller gas generator charged with lignite coal. Although the proportions of hydrogen, carbon monoxide, and carbon dioxide, and steam in the gas correspond in general with the water-gas equilibrium, $CO + H_2O = CO_2 + H_2$, a detailed study of the results leads to the conclusion that the water-gas reaction itself plays little part in the generator reactions. The measurements of temperature correspond with that of the solid fuel. That of the gas must always be higher except at the base of the generator. The gas temperatures have been calculated by drawing up heat balances for different zones of the fuel bed. The differences between the gas and fuel temperatures are greater the drier the fuel. The relation between these temperature differences, the gas composition, the depth of the fuel bed, and other factors is discussed. F.P.H.

Bituminous coal for generator fuel. E. L. FISCHER. *Gas Age-Rec.*, **63** [23], 785–86 (1929). F.P.H.

Testing fuel oil. W. RONALD LESTER. *Glass Ind.*, **10** [7], 163–64 (1929).—Fuel oil is defined as any petroleum product used for the generation of heat in a fire box. In general, it is any liquid or liquefiable petroleum product that is useless from the standpoint of recovering the volatile fractions. The fuel oils in general use may be grouped into (1) crude petroleum, (2) distillate fuel oils, (3) residual fuel oils, and (4) blended fuels. These different classes are defined. With fuel oil, just as with other fuels, a constant check on their purity is required. In the testing of fuel oil the accuracy of the tests depends mainly upon the care taken in securing a representative sample. Fuel oil is shipped in tank cars and top, middle, and bottom samples should be taken with a "car thief." These samples should be combined and thoroughly mixed to form the laboratory sample. The tests usually made on fuel oil are specific gravity, flash point, fire point, viscosity, moisture, sediment, sulphur, heating value, and sometimes the cold test. All these are made according to the standard methods used by the Government (*Tech. Paper*, No. 323A). Brief summaries of each method are given along with definitions of the various terms. E.J.V.

Low-temperature carbonization of fuels. C. ROSZAK. *Gas Age-Rec.*, **63** [26], 900 (1929).—The coal, dried and preferably preheated to about 200°C, is carried through the distillation chamber by means of a continuous chain grate, and is carbonized princi-

pally by the sensible heat of a current of hot gas which is passed down through the coal and the grate, but also by direct radiation from above, the roof of the chamber being externally heated by combustion of part of the gas produced. The Hereng process may be used in conjunction with steam-rising plant, the grate then being extended to carry the coke directly into the combustion chamber, wherein the excess gas may be burnt. To produce a compact coke a heavy endless chain mounted within the chamber rests on the surface of the coal, which is thus compressed as it reaches the softening point. F.P.H.

Value of lignite deposit. ANON. *Nat. Glass Budget*, **45** [7], 23 (1929).—The production of fuel oil from immense beds of lignite, low grade coal, in N.D. would solve the problem of oil supply in the U.S. for many years, should that problem ever come. A deposit in the southwest corner of the state is said to contain 18,000,000,000 T. This is as much coal as has been mined in the U.S. since the use of coal was discovered. (Abstract of a discussion, *New York Journal of Commerce.*) E.P.R.

Sulphur content of gases (coke-oven gas). F. HEINRICH AND F. PETZOLD. *Z. anal. Chem.*, **76,** 120 (1929).—On the basis of comparative tests on variations in volume of gases when passed through alkaline H_2O_2 solutions of different concentrations, a method is evolved enabling an accurate titrimetric sulphur determination to be made within 2 hrs. with a gas velocity of 0.21 per min. All organic and inorganic sulphur is extracted with the exception of that from thiophene. A sufficiently accurate average composition is assured by the large volume taken, 20 liters.
(*Trans. Ceram. Soc.* [Eng.])

Thermal insulation of furnaces and kiln. A. E. HUBBARD. *Fuel Economist*, **3,** 169–73 (1927).—By the use of suitable insulating materials radiation losses can, in most cases, be reduced by 75%; the chief exception being melting furnaces where, at the present time, the use of insulation has to be limited to regenerators or recuperators, uptakes, and gas mains, owing to the fact that the operating temperatures are too near to the limit of refractoriness of the lining bricks to permit insulating the crowns and side walls. The material from which most of the insulators for furnaces are made is diatomaceous or infusorial earth. It is particularly suitable as a covering for the crowns of annealing and reheating furnaces. In deciding whether or not insulation can be applied to a high temperature furnace, the softening range of the fire brick used as a lining is, in most cases, the governing factor. (*J.I.S.I.*)

Combustion chambers for pulverized fuel. P. ROSIN. *Fuel Economist*, **3,** 107–11, 161–65 (1927). (*J.I.S.I.*)

Furnace temperatures in pulverized fuel firing. M. G. WALLACE. *Fuel Economist*, **3,** 40–43 (1927). (*J.I.S.I.*)

Achievements in pulverized fuel firing. H. J. VAN ECK. *Fuel Economist*, **3,** 35–40 (1927). (*J.I.S.I.*)

Extraction of tar from producer-gas. ANON. *Fuel Economist*, **3,** 126–30 (1927).—An illustrated account is given of the Smith tar extractor, which has found wide application in America for cleaning producer-gas. The principle of operation involves passing the gas through a diaphragm of spun glass or glass wool, under a few pounds pressure, not with the object of filtering out the tar, but of causing the particles of the tar-fog to combine and form particles too large to be held in suspension by the gas. The efficiency of the extractor under suitable conditions is as high as 99.5%.
(*J.I.S.I.*)

Factors in pulverized fuel firing affecting economical combustion and boiler design. ANON. *Fuel Economist*, **3,** 351–58 (1928). (*J.I.S.I.*)

Economic and engineering outlook of the gas industry. G. I. VINCENT. *Gas Age-Rec.*, **64** [1], 3–4 (1929). F.P.H.

BOOKS

Carbonization Technology and Engineering. JOHN ARMSTRONG. Charles Griffin and Co., Phila., Pa. 471 pp. Price $17.50; reviewed in *Min. and Met.*, **10** [271], 359 (1929).—Contents: constitution of coal; geological formation; refractory materials; preparation of the coal; theory of coking; charcoal; carbonization of coal; development of the Beehive oven; carbonization of coal in horizontal by-product ovens; coke ovens, vertical type; discharging and quenching of coke and disposal of breeze; coal carbonization by-products; gas manufacture; low-temperature carbonization; economic combustion of fuel; index. This treatise gives a concise yet comprehensive view of carbonization practice, particularly by-product coking. A. has been engaged for forty years in designing and building industrial furnaces and investigating fuels. His book incorporates his conclusions, as well as the views of other authorities. F.P.H.

Proceedings of the Second International Conference on Bituminous Coal. Carnegie Institute of Technology, Pittsburgh, Pa., 2 vols., 900 pp. (each vol.); reviewed in *Can Chem. Met.*, **13** [6], 48 (1929). E.J.V.

World Fuel Conference. 3 vols., index. Lund Humphries, London, 1929. Price £12; reviewed in *Chem. and Ind.*, **48**, 653 (1929).—A collection of the views of the world's authorities on fuel for 1928. H.H.S.

PATENTS

Tunnel kiln. WILLIAM LEE HANLEY, JR. U. S. 1,720,550, July 9, 1929. A tunnel kiln having a unitary tunnel structure throughout its length, the central portion of the kiln forming two consecutively arranged unitary firing zones, and the opposite end portions of the kiln forming unitary cooling and preheating zones, kiln being provided with parallel goods conveying means, movable in opposite directions, each of which passes through each of the cooling and preheating zones and each of the firing zones, heating means for each of the firing zones including direct-fired furnaces discharging their products of combustion into the firing zones, the furnaces for each firing zone being located on the opposite side of the kiln from the furnaces for the other firing zone, means for independently regulating each of the furnaces for each of the firing zones to maintain a gradually increasing temperature in each firing zone from the entrance end thereof toward the other firing zone, each of the firing zones being provided with eduction ports located at different points transversely thereof, and means connected with the eduction ports for withdrawing the products of combustion.

Continuous kilns. NOVELLI. Brit. 309,547, June 6, 1929. In continuous furnaces or kilns in which the fuel is burnt within the mass of goods to be heated, the goods are stacked so that vertical channels extend below the fuel-charging openings and in these channels grids are provided decreasing in mesh from top to bottom so that on supplying fuel charges of successively larger material the first charge passes the upper grids and is caught by the lowermost, the second charge, of larger material, is caught by the next highest, and so on, with the result that on ignition combustion takes place simultaneously at different levels.

Firing bricks, etc. A. HEUER. Brit. 310,315, June 19, 1929. To facilitate the firing of brick, tile, etc., fuel in a finely-divided state is mixed with the raw materials in a proportion which does not exceed that required for the firing process. When the quantity of fuel provided is less than that required for firing the brick, etc., the additional heat necessary may be obtained by sprinkling additional fuel in a finely-divided state between the bricks, etc. The fuel may be added to the raw material in a mixer and the mixture then passed between rollers. The fuel may be finely-divided coke.

Tunnel kiln with vaulted cooling zone and channeled side walls. HEIMSOTH & VOLLMER, G. M. B. H. Ger. 470,834, Dec. 24, 1926. (*C.A.*)

Multiple chamber kiln for ceramic materials. ROBERT MALVOS AND MARCELLIN CROCEMARIE. Ger. 471,409, Nov. 29. (*C.A.*)

Feeding fuel to brick kilns. LAURITZ A. CHRISTENSEN. Fr. 646,636, Dec. 31, 1927. (*C.A.*)

Fuel charger for brick kilns. ERNST SCHOEPKE. Austrian, 112,228, Sept. 15, 1928. (*C.A.*)

Charging and discharging ceramic furnaces automatically. SOC. D'EXPLOITATION DES PROCÉDÉS HIDOUX. Fr. 645,266, Nov. 5, 1927. (*C.A.*)

Geology

Use of clays and allied minerals in industry. SEV. SCHUTZ. *Tonind.-Ztg.*, **52** [70], 1426 (1928).—A general description of clays that are suitable for the manufacture of various products is given. F.P.H.

Structural reasons for oriented intergrowths in some minerals. JOHN W. GRUNER. *Amer. Mineral.*, **14** [6], 227–37 (1929).—Oriented intergrowths as seen especially under the metallographic microscope are discussed. It is found that intergrowth takes place only on those crystallographic planes in which the atomic arrangement and spacing are almost alike. Differences do not exceed a few per cent. At least one of the chief chemical constituents (element or radical) of the two minerals is found in both. There is good reason to believe that one of the structural planes is shared by both minerals at the contact. In the examples investigated the common contact plane seems to be an oxygen or sulphur plane. Reasons are given for the probable nonexistence of oriented intergrowths in mixtures of pyrrhotite and pentlandite. F.P.H.

Capsular silica. FREDERICK A. BURT. *Amer. Mineral.*, **14** [6], 222–26 (1929).—Three specimens of capsular silica have been collected by B. from the Quaternary formations of Brazos County, Tex. Clastic fragments of petrified wood are very common in these formations, and much opal and botryoidal chalcedony is found as veins and incrustations with the wood. The Tertiary and Quaternary formations are exceptionally rich in precipitated silica which occurs as quartz, chalcedony, and opal. The capsular silica occurs as a layer occupying the position of a replacement of the bark of the wood. The layer averages 4 to 5 mm. in thickness, with a maximum thickness of 15 mm. The appearance of the mineral is that of a group of fully and partially developed isometric crystals of cubic habit, superimposed upon the free faces of which are regular capsules arranged in two systems at right angles to each other. The cubes are variously oriented and interlock with one another. The mineral is translucent, and nearly colorless to pale blue in small pieces or thin sections. When viewed in mass a light agate blue is pronounced. The luster is similar to that of opal. No cleavage was observed and the fracture is typically conchoidal. Hardness of the capsules is 6.5. Specific gravity 2.63. They are slowly soluble in potassium hydroxide. F.P.H.

Beryl possibilities in New Hampshire. H. N. KIRK. *Rock Prod.*, **32** [13], 49 (1929).—As the tendency today is to refine ores at the source of the ore or nearest power available, it makes Cold River, N. H., or Bellows Falls, Vt., both located on the railroad, logical locations for a new industry that is now in the process of a pioneer effort of producing beryllium and its alloys from beryl crystals. Beryllium alloys will find many important uses in the aeroplane industry where lightness and strength are desirable. Beryl also has nonmetallic uses such as an ingredient in high-tension insulators of high class and as an ingredient in glass that allows transmission of ultra-violet rays. It is also much sought after in sound crystals of good color for the manufacture of idols by the Chinese. Gem beryls are rare and expert judgment is needed to make known their value. F.P.H.

Colored glazes. A. V. SOLOVIEV. *Ceramics and Glass* [U.S.S.R.], **9**, 240–41 (1928).—According to the definition made by Vernadsky, the mineral *volchonskoite* belongs to the chrome group containing clay, the composition of which can not be expressed by a formula. All clays rich in $H_2Cr_2Si_2O_8$ and forming masses of green color are called *volchonskoites*. *Volchonskoite* purified by chemical treatment contains 53% Cr_2O_3, 46% SiO_2, and 0.5% Fe_2O_3. By adding *volchonskoite* to different fluxes such as galena, alkali-galena, boric-galena and boric, different shades of color, dark brown, orange yellow, gamboge, dark crimson, coral, red, and green, were produced, depending on the percentage added, the degree of its chemical purity, and the temperature. The latter was kept within the limits of from 850 to 950°. It was proved that not more than 5% of the weight of the glaze mass should be used for obtaining transparent glazes. The possibility of obtaining transparent glazes by adding *volchonskoite* is explained by the fact that the Cr, which this mineral contains, is in a fixed chemical combination with SiO_2 and is more easily dissolved in glazes than the chromic oxides from which the glass usually obtains dull green colors. W.A.

Volchonskoite. L. V. PUSTOVALOFF. *Trans. Inst. Applied Min. and Met.* [U.S.S.R.], **36**, 1–53 (1928).—The mineral, *volchonskoite*, which may be of great importance for use as a pigment for coloring ceramic products is described. A historical review of the discovery of the mineral, which goes back about 100 yrs., and the localities in the U.S.S.R. in which volchonskoite has been found are given. The first chemical analysis of volchonskoite was made by Helm, who detected the presence of Cr_2O_3. The chemical constitution of this mineral has been constantly studied since then but no accurate results concerning the chemical nature of it have been obtained so far. The mineral itself is friable, has a grass-green color, a low degree of hardness and a low specific gravity. Volchonskoite does not stand against the action of water. At the surface of the earth it quickly disintegrates under the action of even a few drops of water and when dried is easily blown away, leaving no traces behind. This is the reason why volchonskoite never appears in exposures. The solution of the genesis of volchonskoite and its chemical nature requires much laboratory research. Photographs of samples containing volchonskoite and maps showing places where it occurs are given in the article. W.A.

Japanese kaolinite clays. MINEICHI MASUDA. *Jour. Jap. Ceram. Assn.*, **36** [429], 433–39 (1928).—This report deals with the results obtained from a study of a kaolinite clay produced at Jishahara, near Sawatari hot spings in Shimotsuke. *I. Microscopic Observation:* The clay consists chiefly of minute kaolinite crystals and has a small proportion of hydromica. It contains no colloidal kaolin. (1) *Principal Minerals.* (*a*) *Kaolinite:* Mainly hexagonal plates; angle 120°; size, almost uniform and the length of a side of the hexagon about 0.01 mm.; some crystals fan-shaped; fan-shaped aggregates found; almost colorless and transparent; interference color dark gray; double refraction weak; n_D α 1.560, γ 1.567, hence maximum double refraction 0.007. (*b*) *Hydromica:* Fibrous and minute, though most crystals a little larger than those of kaolinite; almost colorless and transparent; double refraction strong; n_D 1.575–1.590. (2) *Associated Minerals:* Many grains of iron pyrites; some quartz; tourmalin and the other minerals usually accompanied in kaolinite rare. *II. Chemical Composition:* Analysis of a sample, chiefly composed of kaolinite crystals and poor in iron pyrites, is shown in Table I.

TABLE I

Ignition loss	Silica	Alumina	Ferric oxide	Lime	Magnesia	Alkalis (by diff.)
14.02	47.96	36.48	0.93	0.36	Trace	2.25

III. Refractoriness: Cone 26. *IV. X-ray analysis:* An X-ray photograph by powder method is shown. It was impossible to get very distinct lines. *V. Thermal*

Analysis: Heat absorption occurring at 400 and 650°, and heat evolution occurring at 1000 and 1200°, are discussed. *VI. Thermal Expansion:* Temperature contraction curves of primary and secondary heatings are shown. The maximum linear expansion occurring at 600° is 1.7% and shrinkage at 1330° is 11.7%. S.K.

Ocher and ochery earths. R. M. SANTMYERS. Bur. Mines, *Information Circ.*, No. 132, 20 pp. (1929).—Color variations, specifications, substitutes, artificial ocher, mining, beneficiation, domestic deposits, imports and exports, and the French ocher industry are discussed. R.A.H.

Quartz-feldspar rock: Glomero-granular texture. L. HAWKES. *Chem. News*, **138,** 411 (1929).—The name "glomero-granular" is proposed for the texture resulting from eutectic crystallization of fused quartz-feldspar contacts. H.H.S.

Feldspars. I. RHODE. *Keram. Rundschau*, **35,** 615 (1927).—The occurrence and uses and the physical chemistry of feldspars are discussed briefly.

(*Trans. Ceram. Soc.* [Eng.])

Chemical composition of chlorites. J. ORCEL. *Bull. Soc. Franç. minéral.*, **50,** 75 (1927).—The various theories put forward to interpret the chemical composition of the chlorites are discussed. The chemical compositions of a number of characteristic types belonging to the following groups are quoted: magnesian prochlorites, ferromagnesian prochlorites, ferriferous prochlorites, thuringites, and clinochlores. The peculiarites in chemical composition and structure of the chlorites associated with the corundum in the N. Carolina and Transvaal deposits are noted in detail; the term grochauite is applied to them. Methods of studying the physical and chemical properties are discussed, and a new method of chemical analysis is outlined A classification of the chlorites, based on the results of chemical analysis, is presented.

(*Trans. Ceram. Soc.* [Eng.])

Problem of kaolin formation. ANON. *Sprechsaal*, **60,** 589 (1927).—A summary of the work of R. Schwarz and A. Brenner, and R. Schwarz and R. Walcker (published in *Ber. deut. chem. Ges.*, and *Zeit. anorg. Chem.*) (for reference see *Ceram. Abs.*, **4** [12], 357 (1925)) is presented. The theory is put forward that the primary process in the metamorphosis of the feldspar is complete hydrolysis of the feldspar molecule, viz.: $K_2O{\cdot}Al_2O_3{\cdot}6SiO_2 = 2KOH + 2Al(OH)_3 + 6SiO_2$ aqueous, and that, under certain conditions, a synthesis of aluminum hydroxide, silica, and water then takes place.

(*Trans. Ceram. Soc.* [Eng.])

Application of Russian feldspar in the ceramic industry. S. M. KURBATOFF., *Trans. Ceram. Res. Inst.* [Moscow], No. 11 (1928).—The results of an examination of the feldspars from the Murman and Ural districts, and to a less extent from the Caucasus and Siberia, are presented. The Murman feldspar was found to be exceptionally pure, being characterized by its uniformly low content of iron oxide and mica, and the absence of magnesium silicate impurities. Its melting point was 1280 to 1290°, and it gave a clear melt, even when coarse fragments were fused. It represents a valuable material for the manufacture of porcelain. The Ural feldspars vary somewhat in properties as to suitability for porcelain; they are inferior in this respect to the Murman variety, but would also be suitable for porcelain and earthenware manufacture. The Siberian feldspar also proved to be of very good quality, but the Caucasian mineral contained secondary mica, and would require careful sorting.

(*Trans. Ceram. Soc.* [Eng.])

Tungsten as technical material. H. ALTERTHUM. *Chem. and Ind.*, **48,** 573 (1929).—The world output of W is 8000 T. per annum. Both Europe and the U.S. import the ore; it occurs in Asia, S. America, and Australia, as wolframite $(Fe\ Mn)WO_4$ and scheelite, $CaWO_4$. Metallic W is employed for the cores of carbon electrodes to increase their conductivity, and it has a limited use for ovens of temperature 2000 to 3000°C.

In alloys it confers acid-resistance and hardness. The tungstates are used in X-ray work, in making fire-proof material, and in the preparation of lakes. H.H.S.

Geophysical abstracts. II. FREDERICK W. LEE. Bur. Mines, *Information Circ.*, No. 6133, 34 pp. (1929).—A compilation of abstracts prepared from the world's literature. The report covers (1) gravitational, (2) magnetic, (3) seismic, (4) electrical, (5) radio-active, and (6) geothermal methods of prospecting. R.A.H.

Canadian Geological Survey field work of 1929. W. H. COLLINS. *Can. Min. Jour.*, **50,** 554–57, 566–67 (1929).—An account by the Director of the Survey of the 52 parties, employing 250 persons, now engaged in field work in the various provinces of Canada. Of especial ceramic interest is the study by E. Antevs of the stratified clays and the glacial lake deposits along the line of the new Hudson Bay railway. H.H.S.

U. S. Geological Survey. R. L. WILBUR AND H. F. OSBORN. *Science*, **69,** 409–13 (1929).—At the celebration of the 50th Anniversary, U. S. Geol. Surv., in Washington on March 21, W. spoke on science in government, and O. on Thomas Jefferson, the pioneer of American palaeontology. H.H.S.

Present and future state of natural resources. F. M. JAEGER. *Science*, **69,** 437–45 (1929).—Interesting diagrams are given of the growth of consumption of coal, metals, potash, phosphates, sugar, etc., as compared to the increase of population. H.H.S.

Rock suites of the Pacific and Atlantic Ocean basins. H. S. WASHINGTON. *Science*, **69,** 554–55 (1929).—The differences in composition between the rocks of the various continents and ocean floors are attributed to original differences in the molten globe before the earth's crust was formed. H.H.S.

Kentucky Geological Survey. W. R. JILLSON. *Science*, **69,** 422–23 (1929).—Established in Frankfort in 1854 with David Dale Owen as its principal, the Survey this year celebrates its 75th anniversary. H.H.S.

Chromium in wider application. ANON. *Abrasive Ind.*, **10** [7], 26 (1929).—Chromium is coming into wider use in the metal-working industry, according to Donald C. Stockbarger (Mass. Inst. of Tech.). Ore from which chromium is obtained is found in large quantities in many parts of the world, but because of cheap labor 70% comes from Africa. The ore is also found in western U.S., in India, and New Caledonia. The world's supply of the ore exceeds that of copper. In 1926 the world's production was 150,000 T., about 45% of which was used in alloys. Many of the uses of chromium are also given. E.P.R.

Nonmetallic minerals in Canada. BUREAU OF STATISTICS. *Can. Chem. Met.*, **13** [7], 194 (1929).– A new high level in the production of manufactures of the nonmetallic minerals in Canada is indicated by the statistics for 1928. E.J.V.

Feldspar in 1928. ANON. *Glass Ind.*, **10** [7], 171 (1929).—The crude feldspar sold or used by producers in the U.S. in 1928 amounted to about 210,811 long tons, valued at $1,418,975, or $6173 a ton. Feldspar was mined and sold in 12 states, namely, Ariz., Calif., Colo., Conn., Maine, Md., N. H., N. Y., N. C., Pa., S. D., and Va. Detailed statistics are given. E.J.V.

Occurrence of a new sodium alumino-silicate in New Zealand. P. MARSHALL. *Chem. News*, **138,** 411 (1929).—A mineral with low birefringence and low refractive index hitherto taken to be either nepheline or sodalite is shown to be distinct from these and to be nearer microsommite or davyne. It is a sodium alumino-silicate loosely combined with NaCl. It stains dark violet when treated with $AgNO_3$. The name proposed for the mineral is "ameletite." H.H.S.

BOOKS

Genesis of Some Types of Feldspar from Granite Pegmatites. OLAF ANDERSON. Reprinted from *Norsk Geol. Tids.*, B-Xh, 1–2, pp. 116–205 (1928); reviewed in *Amer.*

Mineral., **14** [6], 241–42 (1929).—A. recognizes that perthites may have been formed largely through three different processes: (1) simultaneous crystallization, (2) exsolution, and (3) replacement. The first and second theories are based upon hypothetical phase-rule diagrams. Notwithstanding the stimulation which these diagrams have had on feldspar investigations, N. believes that their importance as expressions of actual phase relations has been exaggerated. Some of the feldspar problems independent of the hypothetical phase-rule diagrams are discussed. A large portion of the paper is devoted to a description of chemical and optical studies of feldspars from granite pegmatites of Norway. A number of interesting terms used in connection with these are (1) string perthite, where the blebs of albite form very small, narrow rods; (2) film perthite, where the blebs assume thin plates running in a direction perpendicular to (010) to an angle of about 73° to (001). Other directions which these films may take are: (3) vein perthite, which is self-explanatory; (4) patch perthite: allied genetically with the vein perthite; the blebs are elongated in the direction of the *b*-axis as well as the *c*-axis. Interlocking perthite and antiperthite are also mentioned. There are 48 photomicrographs of different types of feldspars from Norway. F.P.H.

Investigations of Mineral Resources and the Mining Industry. ANON. Can. Dept. Mines, *Bull.* No. 687; *Rock Prod.*, **32** [12], 93 (1929).—This *Bulletin* contains 14 chapters on the mineral resources of the Dominion, eight of which deal with the nonmetallic industry. The nonmetallic resources of Canada including asbestos, feldspar, graphite, soapstone, gypsum, limestone, and granite are discussed briefly in separate chapters. Two chapters are devoted to preliminary reports on the limestone of Nova Scotia and are covered under separate sub-heads according to their geological classification. F.P.H.

Relationships of Chemical Composition to Refraction of Light, and Density in the Garnet Group. H. V. PHILLIPSBORN. S. Hirzel. 42 pp., 15 figs.; reviewed in *Amer. Mineral.*, **14** [6], 241 (1929). F.P.H.

Geological Comparison of South America with South Africa. A. L. DUTOIT. Carnegie Inst. of Washington, D. C., 1929. Pp. viii + 158, 16 plates, 1 map. Price $3.00. H.H.S.

Chemistry and Physics

Alteration of kaolinite by the heating process. A. S. GINSBERG, CHR. S. NIKOGOSIAN, AND A. W. CHITAEFF. *Trans. Inst. Applied Min. and Met.* [U.S.S.R.], **22**, 1–19 (1926).—A brief review of the literature is given. The investigations of the authors may be summed up as follows: (1) specimens heated to 700–1000° C were slowly cooled; (2) the materials were alkalized by 10% solution of potash and caustic soda; (3) for the tests, pure preparations of silica, alumina, a mixture of the two in the proportion of $2SiO_2$ to Al_2O_3, andalusite, andalusite with one particle of silica and a "clay" called "Borovich Sookhar" were taken; this last corresponds almost exactly to the formula of kaolinite $H_2Al_2Si_2O_8 \cdot H_2O$. Comparing the results of these tests, it becomes evident that the solubility of the mixture of silica and alumina in proportion and of kaolinite hardened at the temperature of 1000° proves to be identical. Those hardened at the temperature of 700° show a perceptible alteration; the alkalinizing of andalusite and of the mixtures with it altered less than did kaolinite. The authors come to the conclusion that at the temperature of 600° during the heating of kaolinite its complete dehydration takes place with the formation of anhydride $Al_2Si_2O_7$. At the temperature of 1000° this anhydride breaks up into free oxides: Al_2O_3 and SiO_2, which with further heating react with each other and probably give, according to Bowen, the combination $3Al_2O_3 \cdot 2SiO_2$. W.A.

Plasticity of clays and kaolins. L. OMININ. *Trans. Ceram. Res. Inst.* [U.S.S.R.], **13**, 1–26 (1928).—O. describes his method of measurements and gives graphic repre-

sentations of the plasticity, richness, and toughness of clays and ceramic masses. The plasticity is determined by the change of the resistance to the cutting force applied to the plastic material with regard to the degree of moisture of the mass. The numerical value of the resistance and of the percentage of water measured for the different physical conditions of the plastic materials are assumed to be the coördinates for the graphical construction of curves. The degree of plasticity, of richness, and of toughness of the material under examination, can be determined by the curve and its position with regard to the coördinate axes. A detailed description of the apparatus constructed for the measurement of the resistance and its use is given; graphs of a series of clays and kaolins are drawn. O. concludes that (1) the numerical value of the plasticity depends on the mechanical force which acts upon the plastic body; and (2) the values for plasticity of the same materials under different physical conditions are different. W.A.

Determining free aluminium oxide in a silicate mixture and application to study of clays. L. SHMELEFF. *Trans. Ceram. Res. Inst.* [U.S.S.R.], No. 14, pp. 1–23 (1928).—The method proposed is based on aluminium oxide forming lakes. Enough alizarin red SX extra was dissolved in alcohol to make the liquid become red, then saturated with boric acid to avoid coloring the silicate mixtures by alkalis and alkaline earths. A small quantity of the silicate was put into a test tube and hot test solution was added; the mixture boiled, shaken continuously, and decanted with hot saturated alcoholic solution of boric acid. In case of a considerable quantity of Al_2O_3 the mass turns a distinct red; less so with decreasing Al_2O_3; 0.04% Al_2O_3 gave distinctly colored sediment. The sensitiveness became less if the mass was previously heated and disappeared entirely when the mass was heated up to 1450 to 1580°. The disappearance of coloring is due to formation of corundum. Corundum does not become colored under any conditions. Amorphous titanium dioxide takes the same color as Al_2O_3 which disappears if hydrogen peroxide is added, while the aluminium oxide retains its color. Brown iron ore or iron oxide are usually colored, thus the alizarin in these cases is useless. Samples of kaolinites taken from Ljubin (emerald mines in the Ural Mountains) and Karpovka (Government of Chernigov) were tested by this method. It proved that they contain free Al_2O_3, and that the freeing of aluminium oxide from the kaolinite molecule did not take place within temperature limits of from 550 to 1100°. W.A.

Determination of iron in red lead. L. SPRINGER. *Glastech. Ber.*, **6** [8], 452–54 (1928).—The methods compared are those using (*a*) both 10 and 2 g. samples dissolved in hydrochloric acid and using hydrazine dihydrochloride, (*b*) 10 grams dissolved in nitric acid, and using hydrogen peroxide, and (*c*) 2 grams dissolved in hydrochloric acid and without hydrazine dihydrochloride. E.J.V.

A modern refractometer. W. EWALD. *Chem. Fabr.*, **12**, 133–35 (1929).—One of the most important physico-chemical methods for the determination of purity and concentration of reagents is given by the refractometric method on account of its accuracy and simplicity and giving directly quantitative results. The method is based upon the determination of the refractory index which is to be considered as a typical molecular constant and hence will determine the degree of purity and the concentration on mixtures. Any admixture and every change in concentration will influence the constant. Should there be, in special cases, the refractory indices (taken for one type of light) the same for two or more substances, there would still be another possibility by determining dispersion, *i.e.*, the behavior against other wavelengths. The optical arrangement of the various lenses of the Askania refractometer is illustrated and a photo of the apparatus is given. T.W.G.

Change of volume during use of fired clay bodies. ANON. Bur. Stand., *Tech. News Bull.*, No. 146, p. 57 (1929).—A study of the change of volume of fired clay bodies resulting from an autoclave treatment has been undertaken by the Bureau. Through-

out the investigation a steam pressure of 150 lbs./in.² has been used. Semivitreous bars fired to cone 5+ were first studied by subjecting them to six autoclave treatments for one hour. The average increases in length at the end of treatment (1) were 0.089; treatment (2) 0.108; treatment (3) 0.127; treatment (6) 0.158%, respectively. Weight changes showed a similar rate of increase. The bars which had been given the autoclave treatment were dried for 40 days at 110°C. Measurements taken at various intervals showed successive decreases in length, the final reading showed no changes after 33 days and amounted to 0.057%. Different liquids were next used in a series of tests and all indicated a positive increase in length. The conclusion is that the change in length is not the result of hydration. R.A.H.

Reversible expansion of clayware. V. TOSAKU YOSHIOKA. *Jour. Jap. Ceram. Assn.*, **36** [430], 484–92 (1928).—A study has been made of the effect of method of preparing test pieces upon their reversible thermal expansion (Tables I and II). Then methods of forming and firing test pieces for further investigation are given.

TABLE I. TEST PIECES

Test pieces	Composition	Forming method	Water content of bodies
63	100 Gairome clay of Seto + 50 ground quartz	Slip dried naturally	
64	100 Gairome clay of Seto + 50 ground quartz	Cast in a plaster mold	
65	100 Gairome clay of Seto + 50 ground quartz	Molded in a plaster mold	46%
66	100 Gairome clay of Seto + 50 ground quartz	Pressed (500 lbs./sq. in. for 3 min.)	
67	100 Gairome clay of Seto + 50 ground quartz	Pressed (1000 lbs./sq. in. for 3 min.)	
68	100 Gairome clay of Seto + 50 ground quartz	Ditto, but squeezed out between grooves	
70	100 kaolin of Katogun + 50 ground quartz	Slip dried naturally	
71	100 kaolin of Katogun + 50 ground quartz	Cast in a plaster mold	
72	100 kaolin of Katogun + 50 ground quartz	Molded in a plaster mold	30%
73	100 kaolin of Katogun + 50 ground quartz	Pressed (500 lbs./sq. in. for 3 min.)	14%
74	100 kaolin of Katogun + 50 ground quartz	Pressed (1000 lbs./sq. in. for 3 min.)	12%

TABLE II. POROSITY, DENSITY, AND EXPANSION

Test piece	Fired at 1100°C for 1 hr.			Fired at 1000°C for 1 hr.		
	Porosity (%)	Density	Total expansion at 710°C	Porosity (%)	Density	Total expansion at 710°C
63	45.0	1.57	0.385	46.0	1.52	0.395
64	42.0	1.58	0.395	45.8	1.58	0.390
65	36.0	1.83	0.400	37.5	1.86	0.390
66	32.5	1.92	0.420			
67	33.5	1.90	0.440	30.0	1.99	0.430
68			0.460			
70	50.0	1.48	0.458	50.5	1.48	0.485
71	53.0	1.53	0.457	51.0	1.53	0.500
72	42.0	1.72	0.490	41.5	1.72	0.515
73	33.0		0.520		1.81	
74	34.5	1.82	0.515	34.5	1.82	0.525

S.K.

Reversible expansion of clayware. VI. TOSAKU YOSHIOKA. *Jour. Jap. Ceram. Assn.*, **36** [432], 567–76 (1928).—Experiments have been made on the thermal expansion of Zettlitz kaolin, Kato kaolin, and Gairome clays (plastic kaolins) of Seto, Tokiguchi, and Seikirei. The maximum temperatures were about 750°C. Conclusions: (1) The curves showing the relation between temperature and linear expansion are nearly straight; (2) heat treatment exerts a marked effect upon the expansion; (3) some of the clays heated at 1300 or 1400° show an abnormal expansion at temperatures under 250°; (4) the curves of the clays heated at 1500° are practically straight and the expansions are smallest, the coefficient of expansion ranging from 0.0528 to 0.0535. S.K.

Determination of transition point by dilatometric method. MOTOTARO MATSUI, SUTEZO OGURI, HEISHICHI ISHIKAWA, AND SHIRO ISHIDA. *Jour. Soc. Chem. Ind.* [Japan], **32** [1], 28–34 (1929).—Hitherto no attention has been paid to the theoretical part of the dilatometric method of determining transition point. In the present communication, the method is treated more mathematically than in observations hitherto published. S.K.

Study of clay slip. I. Experiments on electrolytes, fluidity, and hydrogen ion concentration. TOSAKU YOSHIOKA AND TATSUO IRIE. *Jour. Jap. Ceram. Assn.*, **36** [427], 312–23 (1928).—A study has been made of viscosity and hydrogen ion concentration of clay slips. Gairome clays of Tokiguchi and Seto have been used. Conclusions: (1) fluidity and p_H value of the clay slips are increased by the addition of alkaline electrolyte within certain ranges and the action of acidic electrolyte is just reverse; (2) deflocculating action of sodium silicate or caustic soda is far stronger than that of sodium carbonate or ammonia; (3) 0.16 to 0.24% of the alkalis are sufficient for the minimum viscosity and the corresponding p_H value varies from 7.50 to 10.00; (4) fluidity is a little increased by aging. S.K.

Fine structure of quartz. H. W. ELKINTON. *Rock Prod.*, **32** [12], 50–51 (1929).—As research increases, the characteristic forms of crystals become better known. The question as to why crystals assume exactly the shape they do is discussed. Study of this phase would lead too far afield. A crystal that has assumed a definite shape will change its leptonic arrangement without a catastrophe to the whole structure. At 575°C, the arrangement of the leptons shifts from a trigonal crystalline system into an hexagonal system. If the temperature again falls below 575°C the leptons slide back again into their former formation. The photographic proof of these changes is part of the work of the Laue diagrams, "Crystals and the Fine Structure of Matter" by Rinne. There seems to be a general agreement in the explanation that this actual change in structure must be the result of a gradually-developed tension in the structure of the crystal itself, which increases up to a critical point where there is a sudden change. Leybolt was the first to observe that the indentation on the several faces of the pyramid were different. Three faces, when corroded, gave intensified lines or striae. These are just visible to the naked eye. The other faces developed triangular figures of corrosion, for the most part equilateral triangles. Des Cloiseaux improved on the experiments and reduced the striae to tiny isosceles triangles, similar to those observed on a natural crystal. George Friedel reconciled this difficulty by noting that above 600° the triangles were developed under corrosion of hot alkali whereas under 600°C (probably 575°C) the striae appeared on three faces. This phenomenon agrees with what was found to be the critical temperature for the α-β leptonic arrangement. F.P.H.

Investigation of grain size of clays and soils. JOHANNES GRENNEZ. *Tonind.-Ztg.*, **52** [88], 1747–49 (1928).—A new type of sedimentation apparatus for the determination of the distribution of particle size in clays and soils is described. F.P.H.

Crystal structure types. JOHN W. GRUNER. *Amer. Mineral.*, **14** [5], 173–81

(1929).—The fundamental law governing the structure of crystals, according to V. M. Goldschmidt, may be expressed as follows: The structure of a crystal depends on the relative quantities, sizes, and the deformability of its components. The components may be atoms, ions, and groups of atoms or ions. An attempt has been made to present in a condensed form some of the recent investigations of crystal-structure types especially those of Goldschmidt. Structure types and their valence coördinate bonds are discussed and illustrated. Morphotropism, polymorphism, the formation of radicals due to the deformability of ions, and the effects of counter-deformability are explained with the aid of simple structure types. F.P.H.

Accurate analysis of gas mixtures. ANON. *Gas Age-Rec.*, **64** [1], 18 (1929).—One difficulty with usual methods of gas analysis is found in the deviation of gases like carbon dioxide from the gas law. In the analysis of hydrocarbons this results in serious error in determination of the carbon dioxide contraction ratio. Other errors result from solubility of gases in absorbing solutions, inaccurate gas burettes, poor meniscus in the burette due to dirty mercury, adsorption and occlusion of gases in the copper and copper dioxide in the combustion tube, uncertain temperature and volume of dead space in the manifold, leaks and absorption of gases through stop-cock grease and rubber tubing, etc. Although for a rapid and convenient analysis the standard types of apparatus are probably about as satisfactory as can be hoped for, a more accurate method is desirable in particular instances. F.P.H.

Microscopic investigation of ceramic raw materials. H. MÖHL. *Ber. deut. keram. Ges.*, **10** [2], 105–29 (1929).—The application of the polarizing microscope to the study of ceramic raw materials is described. Photomicrographs of several German clays are shown. F.P.H.

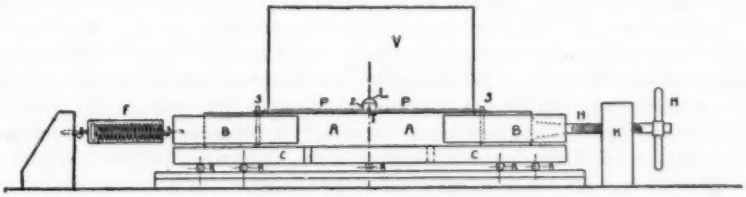
Laws of motion of particles in fluid. R. G. LUNNON. *Min. and Met.*, **10** [271], 333–35 (1929).—Attention is called to the graph evolved by Lord Rayleigh, which is said to be applicable for spheres of all sizes settling in fluids of all densities and all viscosities and thus can be used over the entire range covered piecemeal by the law of Stokes, Allen, and Newton. L. points out that the Rayleigh graph, based as it is on the behavior of individual spheres settling freely, comes no nearer to giving an accurate statement of the performances of irregular mineral particles in crowded settling than do the better known formulas. From a study of the published experiments of Richards, de Caux, Copper and Wilson, Martin, and Gooskov, L. develops new coefficients for certain of the present formulas for settling of mineral particles in water and shows the extent of the approximation of the experimental facts to the generalized mathematical statements. L. notes finally that fluid resistance to nonuniform fall is greater than when the fall is uniform, and suggests taking care of this increased resistance during acceleration by adding to the term for particle mass an amount between $^1/_2$ and $^1/_{10}$ the mass when the fluid is air, and rather less when the fluid is water. F.P.H.

Useful petrographic methods. CHARLES MILTON. *Science*, **69**, 382 (1929).—Describes simple ways of using the microscope for locating under high power, for determining refractive index, and for securing interference figures. H.H.S.

Manufacture of aluminum chloride from clays. I. E. ADADUROV. Kharkov State Inst. Appl. Chem. *J. Chem. Ind.* [Moscow], **5**, 1288–92 (1928).—Seven samples of Don basin clays containing 45.6 to 52.3% SiO_2, 33.07 to 39.5% Al_2O_3, a little of other oxides and moisture, were studied with a view of their utilization for direct conversion to $AlCl_3$. The first operation is the removal of H_2O by firing to 600°. This affects the solubility of Al_2O_3 in acids. When kaolin is heated to 600° its solubility in HCl increases at the rate at which it loses H_2O; in the interval between 600 and 800° the solubility remains constant; at 900° it becomes perceptibly lower; and above 1000° the product becomes almost insoluble. The clays which are most soluble in HCl of

H_2SO_4 are those which have been heated between 600 and 800°. Within the temperature interval 500 to 800° kaolinite does not decompose into free SiO_2 and Al_2O_3, but forms a new silicate which is soluble in acids; hence the soluble constituents of calcined clays are not the free SiO_2 and Al_2O_3, but kaolinite. Hence the importance of determining the kaolinite contents of clay samples. The method is as follows: A known weight of non-calcined clay is boiled 1 hr. in a beaker containing 10 cc. of 20% HCl per g. of clay. One-half of the undecomposed residue is again boiled with 20% HCl for 1 hr., while the other half is first heated to 600 to 800° and then boiled 1 hr. with 20% HCl; Al_2O_3 is determined separately in the 2 liquids and SiO_2 is determined by treating the 2 undissolved residues with 50 cc. of a solution 5% Na_2CO_3 and 0.5% NaOH and with 25 cc. of a solution of KOH per 1 g. of residue. The difference between the Al_2O_3 quantities contained in the 2 filtrates is the Al_2O_3 content of the kaolinite; on multiplying it by 2.533 the kaolinite content of the clay is found, the quantities of SiO_2 found serving as a check. For the transformation of clays into $AlCl_3$ it is best to use an agent containing Cl in active form. Budnikoff (*C. A.*, **18**, 2058) has shown that $COCl_2$ is more effective than Cl, particularly at 1000° in the presence of C. A. believes that the superiority of $COCl_2$ over Cl is due to the circumstance that the former dissociates at 800°, yielding nascent Cl which is more effective than ordinary Cl. The experimental fact that the yield of $AlCl_3$, which is 98% at 1000°, drops to 56.3% at 800° when operating with $COCl_2$ during the same length of time, is explained by the circumstance that at 800° the dissociation of $COCl_2$ is just beginning and, consequently, there is much less active Cl present than at 1000°. Budnikoffs' equation $Al_2O_3 + 3COCl_2 = 2AlCl_3 + 3CO_2$ should be regarded as a reversible reaction, since at about 1000° some of the $AlCl_3$ formed is converted back to Al_2O_3 under the influence of the CO_2 present. This explains the rôle of C, which Budnikoff considered as a catalyzer, but which in reality takes part in the reaction by reducing CO_2 to CO. The best effect is obtained when charcoal and clay are not only intimately mixed with each other, but cemented with mazouts or crude oil into porous briquets which absorb Cl. A real catalyzer in the reaction is KCl in the quantity of 5 to 10%; in its presence the reaction is accelerated, the yield is improved, and the operating temperature may be lowered to 720 to 750°. $FeCl_2$ formed in the course of chlorination of clay can easily be separated from $AlCl_3$, as it is volatile at 400 to 450°. The latter circumstance may be utilized for obtaining $Al_2(SO_4)_3$ free from Fe either by starting with chlorinated clays or by chlorinating $Al_2(SO_4)_3$. (*C.A.*)

An apparatus designed by A. G. Gagarin for the determination of the plasticity of clay. N. K. LAKHTIN. *Trans. State Exptl. Inst. Silicates* [Moscow], No. 21, pp. 25–27 (1927).—The clay sample, *AA*, is placed between the clamps, *BB*, which in construction are similar to those of the Michaelis apparatus. Because of the weakness and flexibility



of the clay the sample, *AA*, is underlaid by a platform, *CC*, which can be moved apart. In order that the clay will not stick to the platform, parchment paper or powder is put on it. The platform rests on a carriage with 5 rollers, *R*, over which both parts of the platform may easily move when the clay sampled becomes elongated. To one

of the clamps a dynamometer, *F*, is attached. To the other clamp a screw, *H*, is attached. To determine the stretching of the sample a special contrivance is made. With the aid of a light ray it gives automatically the deformation (stretching or elongation) of the clay sample and the increase in the tension which stretches it. This contrivance consists of 2 spiral weak springs, *P;* one is a left- and the other is a right-hand spiral. Both springs have one end attached to the joint-pins, *S*, which are placed in the "heads" of the clay sample; the other ends of the springs are fastened together. At the place of their junction, *T*, a light mirror, *Z* (0.5 mm. square) is fastened, which reflects the light ray falling on it from the light of the lamp, *L* (prepared specially for projection purposes). To receive the light ray there is a curved surface, *V*, on the carriage. On this surface a paper sensitive to light is placed. By increasing the tension of the dynamometer spring without changing the length of the clay sample the light ray will give a straight line at the lower edge of the sensitive paper. If the sample becomes deformed without an increase in the strain on the spring of the dynamometer, both spiral springs are stretched equally; because of that, the mirror will not move over the axis of the sample, but it will turn because of the stretching of the springs, which causes the springs to unwind equally. Under such conditions the light ray will give a straight line along the left-hand edge of the sensitive paper. By a simultaneous increase of the tension on the dynamometer (increase of the pulling strains in the clay sample) and of the deformation of the sample, the light ray will give a curve indicating the information desired. (*C.A.*)

The electrical conductivity of silicon carbide. H. J. SEEMANN. *Physik. Z.*, **30**, 43–44 (1929).—Resistance measurements were made with 6 selected crystals of silicon carbide at room temperature and at −80°. The ratio $R_{-80°}/R_{-17°}$ lies between 4 and 6. The specific conductivity is about 0.1 ohm. Conclusion: Silicon carbide exhibits partly electrolytic and partly metallic conductance. (*C.A.*)

Structure of leucite and complex kaolinates. MIECZYSLAW DOMINIKIEWICZ. *Roczniki Chem.*, **8**, 542–52. (German résumé, pp. 552–53 (1928).)—Leucite is interpreted as a derivative of a kaolin anhydride. Its structure approaches that of orthoclase, both natrolite radicals of the kaolin nucleus being linked to potassium silicate nuclei so that the kaolin nucleus is not completely saturated. The structural formula proposed for leucite accounts satisfactorily for all changes of the mineral. From the structural diagrams of andalusite, sillimanite, and cyanite the structural isomerism is evident, which is in agreement with the stability of the individual members. These 3 minerals are assumed to be common kaolin aluminates. The possibility of the existence of an ordinary aluminum silicate differing from the mentioned minerals is discussed. The constitution of andalusite is analogous to that of topaz. The difference consists in $-Al=O$ groups of the former being displaced by $-Al=F_2$ groups in topaz, which is a kaolin fluo-aluminate. The same constitution must be ascribed to the tourmalines, in which B is linked to the aluminate side of the kaolin nucleus, *i.e.*, to the natrolite radicals. A total analogy is found between orthoclase and beryl. Both natrolite radicals of the kaolin nucleus in the 8 Al radicals are saturated with 8 Be-silicate radicals. Euclase, a derivative of beryl, is interpreted as a basic Be kaolinate. (*C.A.*)

Well-crystallized blast-furnace slag. (Melilite-schefferite-olivine.) FRANZ ANGEL. *Z. Krist.*, **68**, 157–76 (1928).—A thin section of the slag shows 55% melilite and 45% of pyroxene, olivine, and glass, with the ratio of pyroxene to olivine about 3:1. According to the fractional chemical analysis the melilite consists of 70% sarcolite ($Ca_3Al_2Si_3O_{12}$) and 30% åkermanite ($Ca_2MgSi_2O_7$); the pyroxene approximates schefferite; and the olivine consists of 65% Mg_2SiO_4, 30% Mn_2SiO_4, and 5% Fe_2SiO_4. This slag is compared with other slags and with natural rocks. (*C.A.*)

Plasticity. H. A. J. PIETERS. *Chem. Weekblad*, **26**, 18–24 (1929).—A review of

plasticity, its determination (direct and indirect) and of theories of the causes of plasticity with particular reference to clay. At least part of the confusion in matters of plasticity is due to the frequent use of clay as a test object where a homogeneous substance would allow more sharply defined conclusions. The plasticity of "clay" is that of a mixture of a nonplastic substance and water; it depends on the clay species, the amount of water, on electrolytes or organic substances present, etc. An elaborate bibliography is given in footnotes. (*C.A.*)

Plasticity. V. Plastic masses of various inorganic substances and their ceramic utilization. O. RUFF AND A. RIEBETH. *Z. anorg. allgem. Chem.*, **173**, 373–94 (1928).—All solids which are wetted by a suitable liquid which does not dissolve them will form a plastic mass of the second order with that liquid if they are in a sufficiently finely divided form. Silica, WO_3, and red phosphorus give good plastic masses with water alone; other solids require an acid electrolyte, and the strength usually increases with decrease of p_H. The formation of these masses is due to electrolytic dissociation of an adsorption complex with the generation of an electric charge on the surface of the solid and the formation of liquid shells around the solid particles. Al_2O_3 when stirred in 0.05 to 0.1 *N* HCl forms a slip which, when cast in plaster molds, air-dried, and fired at 900°, then at 1600°, yields dense, hard, and strong ware. For making zirconia crucibles the pure oxide is fired at 1200° and ground for 20 hrs. in water, HCl is stirred in to 0.2 *N*, the supernatant liquor removed after 2 days' settling, the plastic mass dried at 120° to 2.5% moisture and pressed into shape under 1000 atmospheres. The shapes after firing at 2200° form a fine porcelain-like mass which will not fracture when quenched from a white heat. Good results are obtained from a zirconia slip made from oxide which has been calcined at 1400° and ground in 0.2 *N* HCl; the slip is cast in plaster, and the shapes are slowly dried, preheated at 1000°, brought slowly up to 1200 to 1500°, and finally fired at 1700°. Ceria and titania crucibles are made similarly, using *N* HCl and firing temperatures of 1500 and 1400°, respectively. Silicon carbide gives good results when ground with *N* HCl and the castings are fired at 1500°, but magnesia shapes obtained by any of the above procedures usually break on firing. (*C.A.*)

Dehydration of kaolin. H. A. J. PIETERS. *Diss.*, Delft, 148 pp. (1928).—Kaolin, alumina, and silica are hygroscopic. Kaolin exhibits three heat changes: at 100°, escape of moisture; at 600°, dehydration; at 950°, exothermal decomposition. In the dehydration experiments air saturated with water vapor at different temperatures was passed over kaolin and the temperature determined for each aqueous tension at which the substance lost weight. Curves afford the following values of p: 17 mm. at 430°, 149 mm. at 475°, 355 mm. at 505°, 760 mm. at 540°. The heat of dehydration is computed as 300 g.-cal. per g. Dehydration of more than 13% was obtained for p_{H_2O} 0 at 470°, 17 mm. at 490°, 149 mm. at 510°, 760 mm. at 580°, and 3.6 atm. at 640°. Dehydration of pholerite is slower, corresponding temperatures for the first three values of p_{H_2O} being 510°, 510°, and 560°. The dehydration accords with that of a solid solution of water content x. Between 3 and 13% H_2O the equilibrium is univariant. Meta-kaolin (dehydrated kaolin) does not absorb any water at suitable temperatures below 700° for $p = 149$ at 760 mm. When heated with water under pressure (125 to 150 atm. at 300°), alumina absorbs 16 to 17% of water, forming a monohydrate; ignition above 1100° destroys the absorptive power. Amorphous silica absorbs 2.7 to 45.7% of water at 80 to 130°. Amorphous (Zettlitz) kaolin absorbs up to 14.7% of water at 50 to 130 atm., the amount depending on the temperature of ignition. The absorptive powers of metakaolin, sillimanite, and a mixture of alumina and silica were measured. Ignition of kaolin above 1100° probably gives sillimanite and crystalline silica. Static determinations of the solution pressure of

kaolin and pholerite agreed with the dynamic determinations. Metakaolin contains neither free silica nor alumina. The alumina from metakaolin dissolves almost completely in hydrochloric acid if the ignition temperature is below 900°. Hydrated metakaolin is insoluble in hydrochloric acid. Metakaolin (produced between 600° and 900°) is probably a kaolin anhydride, $Al_2O_3 \cdot 2SiO_2$. Attempts to synthesize kaolin failed. (*B.C.A.*)

Physical, chemical, and technical properties of clays. I. Plasticity. P. A. ZEMIATCHENSKY. *Trans. Ceram. Res. Inst.* [Moscow], No. 7 (1927).—The methods of determining plasticity published in the literature are discussed and arranged in four classes. The various theories of plasticity are considered, emphasis being laid on the importance of the dispersion phase of solid mineral particles and of the dispersion medium. Experiments showed that the essential properties of a clay are distinctly apparent at particles up to 0.005 mm. It is inferred that all the physical and physicochemical properties of dispersion systems are based on the essential reciprocity between the dispersion phases and the dispersion medium. The reciprocity between the two phases of a heterogeneous dispersion system results in the reciprocal action between two surfaces, *i.e.*, in surface energy. Plasticity, like other properties of clays, depends on the properties of the surface of the mineral particles, and on the water and the size of the specific surface. The nature and degree of plasticity in clays therefore depend on the following conditions: (1) degree of dispersion and specific surface of the mineral particles, (2) respective quantities of particles of different sizes in the clay, (3) shape of the mineral particles, (4) the surface properties to be found in all minerals, and (5) chemical nature of the liquid phase. Tests were carried out in order to find a simple way of expressing the degree of plasticity in figures. Simple apparatus is described, with which balls of clay of "normal" consistency were tested. The degree of plasticity was expressed by the product of the compression of the clay ball and the load under which a split appeared in its surface. This product is called the index of plasticity. This method gave parallel results with Atterberg's method.

(*Trans. Ceram. Soc.* [Eng.])

Determination of small quantities of antimony in the form of stibine. J. GRANT. *Analyst*, **53**, 626 (1928).—With an improved form of the electrolytic March type of apparatus, the complete and rapid removal of antimony from a solution in 0.5 *N* hydrochloric acid in the form of stibine was achieved by means of a swift stream of hydrogen bubbles impinging on the point of an inverted cone lead cathode. Removal of the gas from the electrolytic cell before it was decomposed was insured. Small quantities of antimony (10 to 0.001 mg.) were determined in the presence of other metals.

(*Trans. Ceram. Soc.* [Eng.])

Tungsten and zirconium oxide furnace. W. M. COHN. *Z. tech. Physik*, **9**, 110 (1928); *Chem.-Zentr.*, **I**, 2521 (1928); *Brit. Chem. Abs.*, 1348A (1928).—For furnaces employed below 1500° tungsten wire is used as a resistance material. A furnace of tungsten and zirconium oxide for a temperature above 2000° is described.

(*Trans. Ceram. Soc.* [Eng.])

Measuring grain size. H. SCHNEIDERHÖHN. *Metall u. Erz*, **26**, 189 (1929).—The methods hitherto most widely applied, *e.g.*, screen analysis, micro-analysis, and elutriation, are described, and their advantages, disadvantages, and sources of error are discussed. The principle and the advantages of sedimentation analysis, a method which is now becoming more generally used, are pointed out, and apparatus is described.

(*Trans. Ceram. Soc.* [Eng.])

Rapid method of determining boric acid in borosilicate frit. W. MYLIUS. *Keram. Rundschau*, **35**, 550, 570, 585 (1927).—The literature on the subject is reviewed with the object of developing a rapid method of determining the boric acid content in borosili-

cate, etc., baryta water was tried as a means of precipitating simultaneously such components as silica, carbonates, alumina, lead oxide, etc. By the method described, the boric acid in a borosilicate frit having high lead oxide and alumina contents can be determined rapidly with sufficient accuracy for technical purposes. In a frit containing 14.88% B_2O_3, the maximum deviations found were +0.04% and −0.24% B_2O_3. The analysis can be performed in 125 minutes. (*Trans. Ceram. Soc.* [Eng.])

Tridymitization of quartzites. P. P. BUDNIKOFF. *Keram. i Steklo*, **4**, 81 (1928); *Feuerfest*, **4** [9], 136–38 (1928); for abstract see *Ceram. Abs.*, **8** [3], 222 (1929).

Refractive index of quartz. W. R. C. ADAMS. *Proc. Royal Soc.*, **A121**, 476 (1928). (*Trans. Ceram. Soc.* [Eng.])

Action of dilute acid and of soda solution on mica. A. FIOLETOFF. *Keram. Rundschau*, **35**, 552 (1927).—The action of 10% HCl and 10% soda solution on a black mica (biotite) was studied. All the mica can be removed from a clay by treatment for 10 hrs. with 10% HCl. Treatment with 2% HCl for 2 hrs., repeated three times, leaves more than half the mica undecomposed. If a clay having a high biotite content is heated to dull red heat and treated for 2 to 3 hrs. with 2% HCl, most of the biotite can be removed. (*Trans. Ceram. Soc.* [Eng.])

Advances in ceramics. JERZY KONARZEWSKI. *Przemysł Chem.*, **13**, 168–77 (1929).—A review of methods of testing, with an abundant bibliography. (*C.A.*)

Seventh colloid symposium. H. B. WEISER. *Science*, **69**, 593–94 (1929).—Held at Johns Hopkins, June, 1929. The papers taken included (1) progress in study of clay minerals by Wherry, Ross, and Kerr; (2) apparent specific gravity and moisture content of clays by Cameron and Lineberry; (3) nature of plastic flow by Bingham; (4) surface properties of crystals by Herzfeld; and many others of interest to ceramists. H.H.S.

Physics for engineering students. W. S. FRANKLIN. *Science*, **69**, 389–92 (1929).—Discusses training in analytical thinking, the building up of precise ideas and concepts by definition, and mathematical formulations. H.H.S.

BOOKS

Etymological Dictionary of Chemistry and Mineralogy. DOROTHY AND KENNETH C. BAILEY. Edward Arnold and Co., New York. 308 pp. $10.00; reviewed in *Min. and Met.*, **10** [271], 359 (1929).—The derivation of chemical and mineralogical names that have been current in the literature of the period beginning with the middle of the 19th Century are given. Each word is defined briefly, and the authority for the derivation given. F.P.H.

National Physical Laboratory Report. H. M. Stationery Office. 9s net. Measurements have been made of the transmission factors of a number of window glasses in common use, and samples of these glasses are now being exposed in Westminster. They will be measured periodically to determine the effect of accumulation of dirt, as it is expected that different types of glass will show different results when exposed under similar conditions. A simple "strain-viewer" has been made for examining volumetric glassware after annealing. A polarizing mirror on the base of a wooden box reflects a beam of plane polarized light through a ground-glass window in one side of the box. Apparatus in front of the window is examined through a nicol prism mounted on a vertical brass column. A selenite plate is fixed in front of the analyzing nicol. The production of silicon-carbide muffles of intricate design for the construction of a new type of furnace, of specially lined crucibles, and of fine-bore tubing of pure thoria give an indication of the varied nature of the apparatus which has been required during the year. The development of optical methods of temperature measurement in connection with certain researches has necessitated the production of apparatus to insure "black-body" conditions of measurement. The mechanical strength of crucibles,

etc., of pressed alumina is low, and efforts have been made to increase it. By grinding the material so as to obtain a suitable gradation of grain size it has been possible to obtain a more compact and dense body, with greatly increased strength. Attempts are also being made to increase the mechanical strength of alumina articles where grinding is undesirable. Such apparatus is very fragile in the green state, and it is difficult to fire a large thin-walled crucible without risk of collapse. The effect of acid treatment of the material before firing is being tried, and preliminary results show promise of success in this direction. Work is also in progress with the object of investigating the possibility of making crucibles, etc., from nonplastic materials by the casting process. Small crucibles have been produced with the aid of acid treatment, and investigations are to be continued in this and other directions. The necessity for a high degree of purity in the finished product considerably increases the difficulty of such research. The vigorous reducing action of silicon on refractories, such as alumina when used for the melting of iron-silicon alloys, has been found to cause serious contamination of the alloys. Crucibles of pure silica have been prepared for use with these alloys, and have proved satisfactory. Water-ground quartz is fired to transform the silica, crushed, and molded into crucible shapes. Fired at 1530°C, the product is hard and vitreous in structure. The use of pure thoria as a crucible material has been found satisfactory for many purposes, although, unfortunately, the high cost militates against it. It has, however, been found possible to line alumina crucibles with a wash of thoria, thus producing a successful substitute for crucibles wholly of this material. Reviewed in *Pottery Gaz.*, **54** [625], 1123–24 (1929). E.J.V.

Pyrolysis of Carbon Compounds. CHARLES D. HURD. Chemical Catalog Co., New York. 754 pp. Price $12.50; reviewed in *Can. Chem. Met.*, **13** [7], 48 (1929).—Pyrolysis is defined as the transformation of a compound into another substance or substances through the agency of heat alone. The term "pyrolysis" is considered to be somewhat broader than "thermal decomposition." E.J.V.

Polar Molecules. P. DEBYE. The Chemical Catalog Co., New York. Price $3.50; reviewed in *Can. Chem. Met.*, **13** [6], 48 (1929).—Polarity has been used to determine the geometrical arrangements of atoms. Some interesting new relations between polarity and the phenomena of dispersion and absorption are discussed. E.J.V.

Practical Color Photography. E. J. WALL. New ed., pp. vii + 280. Chapman & Hall, Ltd., London, 1929. Price 15s; reviewed in *Chem. and Ind.*, **48**, 635 (1929). H.H.S.

Properties of Inorganic Substances. WILHELM SEGERBLOM. 2nd ed. Chemical Catalog Co., New York, 1929. 226 pp. Price $6.00. A comprehensive index of common and trade names, and the latest physical data on over 2200 compounds are given. H.H.S.

Studies in the History of the Statistical Method. HELEN M. WALKER. Williams and Wilkins Co., Baltimore, 1929. Price $5.00. H.H.S.

Report of the Committee on Heat Transmission. Natl. Research Council, New York. Report of Sub-Committee on a Standard Test Code for Determining the Thermal Conductivity of Insulations in the Moderate Temperature Field (100–1000°F). E.J.V.

PATENTS

Production of alkali-metal silicates soluble in water. BIRGER FJELD HALVORSEN. U. S. 1,718,292, June 25, 1929. Process for the production of alkali metal silicates soluble in water, consisting in mixing compounds of an alkali metal with nitrogen and oxygen with silicic acid hydrate and heating to 250°C or more, but below the melting point of the mass.

Preparation of sodium-silicate solution. CHARLES D. WOOD. U. S. 1,719,038, July 2, 1929. Process for the production of sodium silicate solution from sodium silicate glass, which comprises agitating successive batches of a mixture of sodium silicate glass and water under superatmospheric steam pressure and at a corresponding temperature in a closed rotary cylinder until the glass is substantially completely dissolved and delivering the successive batches of the resulting sodium silicate solution from the cylinder by the force of the pressure into the bottom of a storage vessel capable of holding a plurality of the batches.

Treating antimonial ores. HENRYK GOLDMANN. U. S. 1,719,657, July 2, 1929. The process of treating antimonial ores to dissolve the antimony and obtain a residue substantially free of antimony which comprises leaching the ore with a non-oxidizing inorganic acid containing a metallic protoxide salt having the property of reducing antimony oxide.

Purification of impure solutions of caustic soda, etc., on osmotic principles. LEONARDO CERINI. U. S. 1,719,754, July 2, 1929. In the process for the dialytic recovery of sodium hydroxide from a solution of the same containing colloidal impurities, the use of a dialytic separator, segregating the body of solution to be purified, from a body of solvent for sodium hydroxide, comprising a diaphragm of mercerized woven textile fabric.

Treating titanium ores. DEUTSCHE GASGLÜHLICHT-AUER-GES., Brit. 309,597, June 6, 1929. In the treatment of titanium ores containing chromium with sulphuric acid with recovery of the latter for re-use, the chromium is removed from the recovered acid by concentration thereof to at least 92% strength, followed by prolonged heating at or above 300°C.

Titanium dioxide. DEUTSCHE GASGLÜHLICHT-AUER-GES. Brit. 309,598, June 6, 1929. Titanium dioxide discolored by chromium is mixed with a small excess of alkali dried, and roasted, and the chromate so formed removed by leaching. The use of alkalis, alkali carbonates, and barium or magnesium oxide, is referred to, and an oxidizing agent may also be added. Residual alkali in the leached product may be neutralized by acid or by means of aluminium or zinc sulphate.

Decomposing leucite. F. JOURDAN. Brit. 309,957, June 12, 1929. Leucite is treated with excess of gaseous nitric acid with or without oxides of nitrogen in the presence of water vapor and air to obtain potassium, aluminium, and iron nitrates admixed with silica. The mixture is dried and heated to decompose aluminium and iron nitrates, but not potassium nitrate, and the latter may be recovered by leaching or the mixture may be used as a manure. The oxides of nitrogen evolved, admixed with water and an amount of nitric acid equivalent to that used in the formation of potassium nitrate, may be re-used in the process. Oxides of nitrogen obtained by the oxidation of synthetic ammonia or from the electric arc process for the fixation of nitrogen may provide the nitric acid required and also the heat necessary to carry out the process which may be effected continuously, in a rotary tube comprising three zones.

Titanic hydroxide. J. BLUMENFELD. Brit. 310,949, June 26, 1929. The hydrolysis, under heat, of titanium salt solutions is assisted by the addition of a small amount of a nucleous liquor containing nuclei of titanic hydroxide which are still capable of being dispersed wholly or partially by dispersing agents into a condition of apparently homogeneous solution. The nucleous liquor may be obtained by hydrolyzing a titanium salt of low acidity under heat with subsequent cooling to stabilize the nuclei produced. *E.g.*, a portion of the main solution may be added to an alkali until the acid concentration of the liquor has a p_H value of 2 to 7 or preferably 4 to 4.5 hydrolysis be effected at 70 to 80°C for 15 to 30 mins., and stabilization be then obtained by rapid cooling to below 60°C.

Ceramic substances. FÉLIX SINGER. Fr. 645,614, Dec. 13, 1927. The coefficient of expansion of steatite or other compounds of Mg and products made therefrom is reduced by adding compounds of Al and heating until the formation of 3 phases. The first phase is a glass, *n* 1.53–1.555; the other 2 are crystallites, crystals of the sillimanite, and crystallized silicates of alkaline earths of the enstatite or forsterite type. (*C.A.*)

General

Masonry engineering. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **8** [7], 181–82 (1929).—Need is pointed out for coöperation between ceramic building material producers and universities and experiment stations in an effort to establish training of students in the use and value of ceramic materials and in the procurement of data and standards that will place ceramic building materials in the high place they really merit, but not demonstrated for construction purposes. E.J.V.

Commencement epigrams. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **8** [7], 182 (1929).—A series of epigrams appropriate for consideration at commencement time is presented. E.J.V.

Laboratory dust-explosion apparatus. C. M. BOUTON, C. H. GILMOUR, AND GARNET PHILLIPS. Bur. Mines, *Rept. of Invest.*, Serial No. 2927, 10 pp. (1929).—Although much valuable work has been done in the study of dust explosions, the laboratory technique has not been developed to the point where the many factors involved can be properly controlled, and thus where really fundamental information can be obtained. A brief discussion of the difficulties encountered in fundamental work on dust explosions, a description of apparatus intended to overcome some of them, and an account of some results obtained are given. The more important factors pertaining to the dust cloud itself which are known to determine the phenomena of explosions are (1) the kind of dust, (2) its fineness, (3) its concentration in the exploding cloud, and (4) the nature of the interior motions, or turbulence, of the cloud before and during the explosion. These factors are arranged in what seems to be an ascending order of complexity. The report discusses these factors in detail. R.A.H.

Sampling dust in rock-dusted mines. C. W. OWINGS. Bur. Mines, *Information Circ.*, No. 6129, 8 pp. (1929).—Rock dust is recommended not only because it renders the coal dust inert to explosibility, but also because the noncombustible condition does not change rapidly in character, as is the case with water. To obtain full benefit of this explosion prevention method the dust must be sampled periodically, preferably monthly, to give a check on the average condition of the rock dust. The report discusses rules for collection of samples, sampling stations, kind of samples and how to collect, and types of sampling equipment. R.A.H.

Waste heat. ANON. *Brit. Clayworker*, **38** [446], 87 (1929).—Waste heat may be defined as the residual heat leaving a process which could be usefully utilized elsewhere. A discussion on ways and means of eliminating or reducing waste heat to a minimum is given. R.A.H.

Safeguarding electrical equipment in mines. I. Great Britain, II. Belgium. L. C. ILSLEY. Bur. Mines, *Information Circ.*, Nos. 6134 and 6135 (1929).—These papers outline conditions in the two countries named for safeguarding electrical equipment so as to avoid ignition of gases in mines. R.A.H.

Developments in mechanized mining. G. B. SOUTHWARD. *Min. and Met.*, **10** [270], 279–80 (1929).—Standard mining methods and practices developed in connection with hand loading of coal are being modified to fit in with mechanical loading devices. In any attempt to classify the type of equipment used in the eastern, southern, and mid-western coal fields, the best that can be given at the present time is an estimate. In anthracite mining, scrapers predominate, but conveyer mining is now com-

ing into use. Mechanical loaders are used to a limited extent for rock work. In the low coal beds of central Pa., scrapers and conveyers predominate in those mines where mechanized mining is being practiced, while in the high coals of western Pa., northern West Va., and Ohio the present trend is more toward the use of mechanical loaders. In Ind., and Ill., most of the beds where mechanized loading is now being used are thicker than 6 ft., and in these states the use of mechanical loaders is far in excess of other types of mechanized equipment. Pit-car loaders within the last year have been considerably used, particularly in Ill. In eastern Ky., southern West Va., Va., and Tenn., it is probable that the number of mines using conveyers, and scrapers is greater than those using mechanical loaders, but it is equally probable that the tonnage in these fields, produced by mechanical loading, will equal that mined with other types of equipment. This is because mechanical loaders are used in the thicker beds of coal while scrapers and conveyers are for the most part confined to low coal. In Ala., Ark., and Okla., conveyer mining on long wall has been operated for a number of years, and mechanical loaders to the present time have been used very little in any of these three states. F.P.H.

Organization of scientific research in industry. F. B. JEWETT. *Min. and Met.*, **10** [270], 272 (1929). F.P.H.

Silicosis. LEROY U. GARDNER. *Sci. Supp.*, **69,** 14 (1929).—Silica or quartz dust aggravates tuberculosis of the lungs more than any other known dust. Silicon carbide and coal dust failed to produce aggravation of the disease, so that the ill effect of silica dust is due to the silica and not to dust itself. H.H.S.

Utilization of waste heat for steam raising in metal works. WINTERMEYER. *Feuerungstechnik*, **17,** 100 (1929).—Various types of waste-heat plants are discussed. (*Trans. Ceram. Soc.* [Eng.])

Electrical hazards. W. M. POWELL. *Cement, Mill & Quarry*, **34** [7], 39–40 (1929).—The paper is a nontechnical discussion of electrical accidents and their prevention. E.P.R.

Overburden problems in hydraulic dredging. ANON. *Cement, Mill & Quarry*, **34** [7], 10 (1929).—The Rapids Gravel Co. have operations of great interest because of their unusual field problems. Their deposits are of hard, sharp sand with an overburden of 10 to 12 ft. which offers very obstinate problems. A pump dredge is employed, as there is an abundance of water and most of the aggregates lie below water level. E.P.R.

Bentonite in making pencil lead. ANON. *Cement, Mill & Quarry*, **34** [7], 46 (1929).—Clay for pencil leads must be absolutely free from grit, and, to achieve this, long grinding or costly refining by endosmotic means is necessary. Purified bentonite would probably be suitable for the manufacture of pencil leads and thus save considerable cost in grinding. The use of some other wetting agent would eliminate the excessive drying shrinkage resulting from the use of water with alkali types. Where grease or wax is used in the mix, bentonite would be found to be of considerable value. E.P.R.

Controlling costs. H. C. KLEYMEYER. *Brick Clay Rec.*, **75** [2], 78–79 (1929).—Budget control puts the plant under a magnifying glass and reveals the profit leaks. By dividing a plant into departments and budgeting each it is possible to keep close check on the cost of manufactures and the leaks. Profits are made through (1) low production costs, (2) the elimination of waste or low grades, and (3) selling all grades at an average price that is higher than the cost. E.J.V.

Lancaster experiment and testing station. ANON. *Brick Clay Rec.*, **75** [1], 40 (1929).—The Lancaster Iron Works is establishing a modern experimental and research department for the development of clayworking machinery in the industry. It is also

contemplated to establish a modern clay test department, in close proximity to the new experiment station, the purpose being to make tests under actual plant conditions, rather than laboratory miniatures. E.J.V.

Texas clays. JACK BAKER. *Brick Clay Rec.*, **75** [1], 34 (1929).—The wealth of raw material for ceramic uses in Texas is described, and the demand for permanent, fire-proof architecture is compelling intensive development of these resources. Clays of economic value are classified in five groups: (1) common brick clay; (2) firebrick clay; (3) slip clay; (4) kaolin; (5) fullers' earth. There is also a boulder clay, and the adobe dirt, used in making adobe brick, particularly in southwest Texas along the Mexican border. Texas produced approximately $6,000,000 worth of clay products last year. E.J.V.

What Russia is doing in ceramics. ANON. *Ceram. Age*, **13**, 87 (1929).—An exhibition of Russian art ware is illustrated and described.

(*Trans. Ceram. Soc.* [Eng.])

Activities of the Leningrad Ceramic Research Institute, 1919–1924. P. A. ZEMIATCHENSKY. *Trans. Ceram. Res. Inst.*, [Leningrad], No. 21, pp. 1–31.—The report comprises the following sections: ceramics, glass and enamels, quartz, mineralogy, chemistry, and physics. (*Trans. Ceram. Soc.* [Eng.])

Activities of the Leningrad Ceramic Research Institute, 1924–1925. V. ISKIUL AND P. A. ZEMIATCHENSKY. *Trans. Ceram. Res. Inst.* [Leningrad], No. 4, pp. 1–59.—Reports of committees on glass-melting pots and high-tension porcelain are presented. Other sections include ceramics, glass and enamels, high-temperature work, chemistry, mineralogy, and physics. (*Trans. Ceram. Soc.* [Eng.])

Design patents. LEO T. PARKER. *Ceram. Ind.*, **13** [1], 37–38 (1929).—Patents are subdivided into classes known as (1) mechanical, (2) process, (3) composition, (4) article of manufacture, and (5) design. (1) Mechanical patents are obtainable on mechanical devices; (2) process patents include any method of making an old or new article, whether by mechanical, manual, or chemical means; (3) composition patents are issued on things made from compositions of matter or mixtures of chemicals; (4) articles of manufacture: patents are granted on articles which are to be manufactured but not included in any of the former classes; and (5) design patents relate exclusively to the external appearance of an article which must be ornamental and attractive. In many instances, persons have been misled into the false belief that a design patent affords protection on the operation, construction, or mechanical elements of invention, but this is not so. A design patent protects only the exterior appearance of the invention, although the mechanical construction is clearly shown in the drawings. On the other hand, while a design patent on a mechanical device is void and of no effect, yet if a mechanical device is ornamental or attractive in shape, the mere fact that it has mechanical advantages does not prevent the inventor from obtaining a valid design patent. F.P.H.

History of science exhibition. ANON. *Chem. and Ind.*, **48**, 658–59 (1929).—Opened at Florence, Italy, in May and continuing until October, 1929. The development of science can be followed from the manuscripts of the early Renaissance and the first scientific instruments and apparatus down to the present day. The old apparatus is notable for the glass blowing, its artistic beauty, and admirable construction. H.H.S.

Chemical industry in Germany. ANON. *Chem. and Ind.*, **48**, 650–52 (1929).—Refining china clay by the process of Graf Schwerin is said to require only 40 kw. hr. per ton. German imports of bauxite have dropped in the last two years, and exports of aluminum have increased. Imports of tin ore show a decrease. It is feared that the London control of the tin market will shut off supplies of ore to Germany. Only

one-half of the German consumption of zinc is covered by home production. Potash sales have increased from 1.1 to 1.42 million tons in 2 years. H.H.S.

Chemical industry in Italy. C. PADOVANI. *Chem. and Ind.*, **48**, 627–28 (1929).—A review which includes reference to the treatment of leucite of which there are enormous deposits in Italy, for the production of K and Al salts and Al metal. Production of Al this year from bauxite and leucite will exceed home consumption. H.H.S.

Third International Foundry Congress. ANON. *The Times*, June, 1929.—Opened at the Guildhall, London, June 11, Wesley Lambert, president. The two previous congresses were held in Paris in 1922, and in Detroit in 1926. H.H.S.

The Ceramic Society's trip to America. A. H. STEPHENSON. *Brit. Clayworker*, **38** [446], 79–83 (1929).—S. reviews the experiences of the British ceramists in America. R.A.H.

A.S.M.E. meeting. ANON. *Abrasive Ind.*, **10** [7], 19–20 (1929).—The spring meeting of the A.S.M.E. (Rochester, N. Y.) was held in May, 1929. E.P.R.

A.S.M.E. to celebrate its 50th Anniversary. ANON. *Cement, Mill & Quarry*, **34** [7], 53 (1929).—Founded in 1880, the 50th Anniversary of the A.S.M.E. will be celebrated in 1930 with ceremonies of international scope. E.P.R.

A.S.T.M. Meeting. ANON. *Cement, Mill & Quarry*, **34** [7], 26 (1929).—One of the important questions to come up before the Atlantic City meeting of the A.S.T.M. is that of a standard specification for special and high early strength Portland cements. At present each of the manufacturers have their own specifications and a standard specification would be of service to contractors and architects. E.P.R.

Ohio Ceramic Industries meeting. ANON. *Brick Clay Rec.*, **75** [2], 96–100 (1929); for abstract see *Ceram. Abs.*, **8** [8], 613 (1929). E.J.V.

Ohio Academy of Science. W. H. ALEXANDER. *Science*, **69**, 678 (1929).—The 39th Annual Meeting of the Ohio Academy of Science was held at Wittenberg College (Springfield, Ohio) April, 1929. The president for the ensuing year is F. C. Waite, Western Reserve Univ. H.H.S.

Techno-psychology: Sixth International Congress. W. V. BINGHAM. *Science*, **69**, 423 (1929).—This congress is to be convened at Barcelona, Oct., 1929. Three leading topics are: (1) critique of tests for industrial fatigue; (2) minimum statistical measures necessary for standardization of a psycho-technical test; (3) methods for studying personality. H.H.S.

American Association of Museums. L. V. COLEMAN. *Science*, **69**, 630 (1929).—The 24th Annual Meeting was held at Philadelphia, May, 1929. Fiske Kemball of the Pennsylvania Museum is the new president, succeeding C. J. Hamlin of Buffalo. National headquarters are now at the Smithsonian Inst., Washington. C. is director. The Association's publications include a fortnightly *The Museum News*, a series of monographs on museum work, and technical studies of museum methods. H.H.S.

International Congresses of 1930. A. S. HITCHCOCK. *Science*, **69**, 566–67 (1929).—A list published by the A.A.A.S. for the information of those planning to attend congresses outside the U.S. is given. The list includes Soil Science at Leningrad, U.S.S.R., in June; geodetics and geophysics at Stockholm in August; applied science at Liège, Belgium, April to Oct.; World Power Conference at Berlin in June; and World Engineering at Tokio (undated). H. as secretary of the information committee is addressed at Smithsonian Inst., Washington. H.H.S.

BOOKS

Homes of Permanence. ANON. *Clay-Worker*, **91** [7], 586 (1929).—The Structural Clay Tile Assn. issued a 65-page book showing pictures and plan sketches of homes, featuring four-, five-, and six-room homes. A variety of structural uses of clay tile in garages, business buildings, oil stations, silos, etc., are also pictured. E.J.V.

Patent Law and Practice. A. W. GRIFFITHS. Stevens and Sons, Ltd., London, 1928. Price 7s 6d net. Reviewed in *Mech. World*, **85** [2209], 422 (1929).—In the professional life of the engineer there are many occasions on which a reliable and up-to-date book on the principles of the law of patents would be of great service. The necessity for an up-to-date volume follows from the fact that English legal practice is an evolutionary process as compared with many foreign systems; the reliability of this book is considerably added to by the fact that its writer was formerly at the Patents Office. E.P.R.

Human Engineering and Industrial Economy. LAWRANCE A. HARTLEY. Marshal Jackson Co., Chicago. 344 pp. Price $3.00; Penton Publishing Co., Ltd., London. Reviewed in *Abrasive Ind.*, **10** [5], 41 (1929). E.P.R.

Ventilation of Mines. Generation of the Air Current. HENRY BRIGGS. Methuen and Co., London, 1929. 139 pp. Price $1.80; reviewed in *Min. and Met.*, **10** [271], 358–59 (1929). F.P.H.

Industrial Explorers. MAURICE HOLLAND. 347 pp. Harper & Bros., N. Y.; reviewed in *Abrasive Ind.*, **10** [7], 29 (1929). E.P.R.

Labor Management. J. D. HACKETT. D. Appleton Co., 691 pp., Price $5.00; reviewed in *Abrasive Ind.*, **10** [7], 29 (1929).—H. is consultant on labor and management problems, and author of "Health Maintenance in Industry." In this book are summarized the best practices of progressive companies in handling labor. It covers the whole range of employer-employee relationships and tells how every detail of personnel administration is organized. E.P.R.

Explosives Service Bulletin. ANON. *Cement, Mill & Quarry*, **34** [7], 31 (1929).—The E. I. duPont de Nemours & Co., have recently compiled an Explosives Service Bulletin. They are grouped according to date of issue and to the class of work to which they are applicable. The lists go back to 1923 and up to 1928. Articles are given on various explosive phases of coal and metal mining, quarrying, tunneling, and general articles in the explosive industry. E.P.R.

Recent Economic Changes. McGraw-Hill Book Co., Inc., New York. Price $7.50; reviewed in *Brick Clay Rec.*, **75** [1], 33–34 (1929).—The findings of a committee of business men headed by Herbert Hoover who made an analysis of post-war development in American economic life are reported. Studies were made by leading economists and business men on practically every important phase of business and industry. Changes and trends on such matters as (1) Consumption and the Standard of Living, (2) Marketing, (3) Labor, (4) Management, (5) Price Movements and Related Industrial Changes, (6) Money and Credit and Their Effect on Business, and many other important phases of business are discussed. The book describes modern business as it is conducted in the U.S. E.J.V.

PATENT

Incrustation preventive. JOHN H. OBERHOLTZER. U. S. 1,720,565, July 9, 1929. A composition of matter for use in removing and preventing incrustations in boilers consisting of the following in substantially the proportions named: starch $^1/_2$ to 5 lbs., and a solution consisting of 1 to 5 lbs. of a hydroxide of an alkali metal in 20 to 100 gal. water, in which solution $^1/_2$ to 5 bu. decayed or rotted wood have been digested.

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Department of Ceramic Engineering *Founded 1905* URBANA, ILLINOIS

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SIX INSTRUCTORS and a research associate *Head of Department:* C. W. PARMELEE

IOWA STATE COLLEGE

Department of Ceramic Engineering, AMES, IOWA

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FOUR INSTRUCTORS *Founded 1906* *Head of Department:* PAUL E. COX

THE UNIVERSITY OF NORTH DAKOTA

Department of Ceramics and Ceramic Engineering, GRAND FORKS, N. D.

Curriculum—Ceramic Art and Technology

FIVE INSTRUCTORS *Founded 1910* *Director:* A. W. GAUGER

UNIVERSITY OF WASHINGTON

Department of Ceramic Engineering, SEATTLE, WASHINGTON

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Coöperation with the U. S. Bureau of Mines

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Curriculum—Ceramic Engineering

TWO INSTRUCTORS *Founded 1921* *Head of Department:* W. G. WORCESTER

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Department of Ceramics, School of Mines and Metallurgy

STATE COLLEGE, PENNA.

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Head of Department: J. B. SHAW *Founded 1923*

GEORGIA SCHOOL OF TECHNOLOGY

ATLANTA, GEORGIA

CERAMIC DEPARTMENT — *Curriculum*—Ceramic Technology and Engineering

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MORGANTOWN, W. VA.

Ceramic option course founded 1924

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TWO INSTRUCTORS AND TWO ASSISTANTS — *Director:* W. A. KOEHLER

UNIVERSITY OF TORONTO

TORONTO, CANADA

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VIRGINIA POLYTECHNIC INSTITUTE

BLACKSBURG, VIRGINIA

Curriculum—Ceramic Engineering

Founded 1929 — *Head of Department:* J. W. WHITTEMORE

UNIVERSITY OF CINCINNATI

CINCINNATI, OHIO

Dept. School of Applied Art, Ceramic Dept.

Curriculum—Coöperative training in ceramic art and technology to develop designers for ceramic industries

Founded 1926 — *Head of Department:* HAROLD S. NASH

THE OHIO STATE UNIVERSITY

Department of Fine Arts, COLUMBUS, OHIO

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THIRTEEN INSTRUCTORS — *Head of Department:* JAMES R. HOPKINS

Founded 1927 — *Professor of Ceramic Art:* ARTHUR E. BAGGS

UNIVERSITY OF OKLAHOMA

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Founded 1927 — *Head of Department:* JOHN N. FRANK

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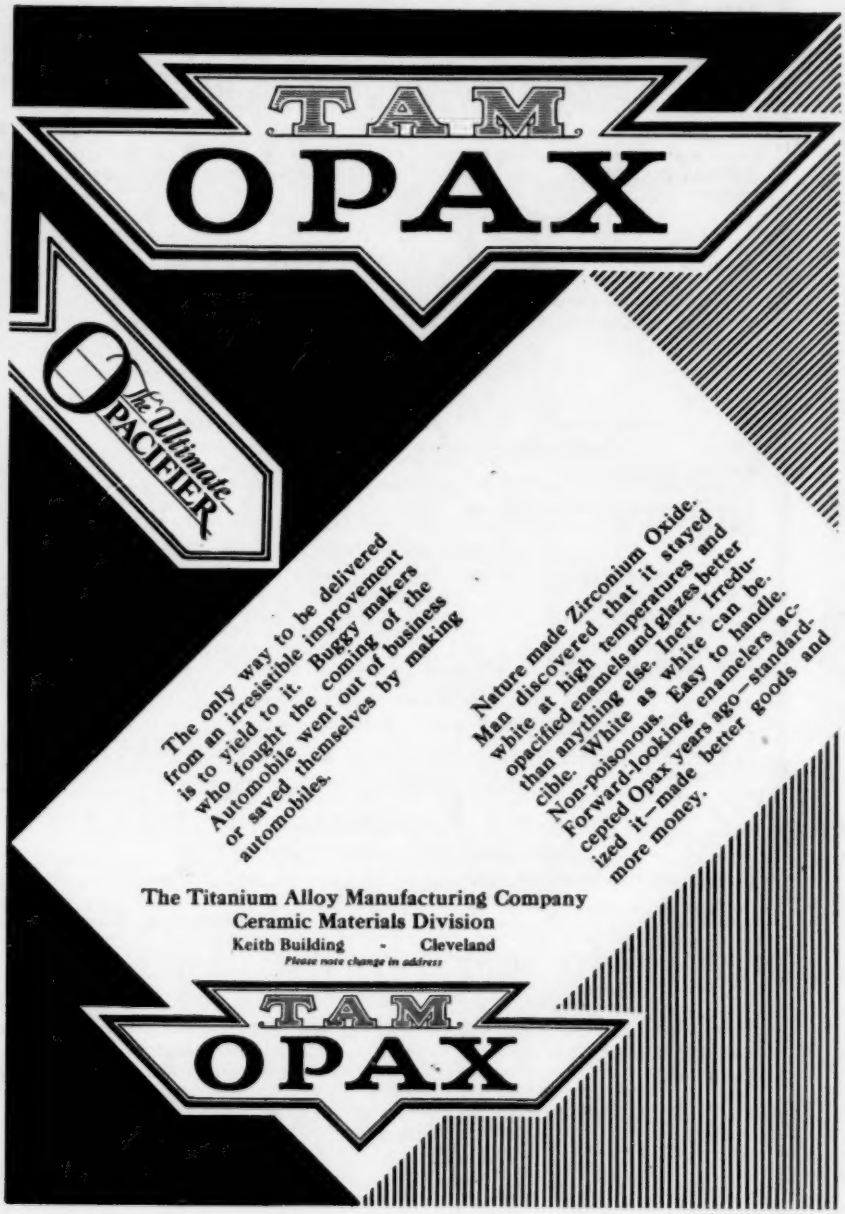
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BULLETIN

of the

AMERICAN CERAMIC SOCIETY

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific, and Art Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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Vol. 8 **September, 1929** **No. 9**

EDITORIAL

CERAMIC RESEARCH[1]

BY J. W. MELLOR[2]

After my visit to the States about two or three years ago, I eagerly looked forward to coming with all my friends. In past years, your Secretary and I have corresponded at various times with the idea of arranging a visit, but only now has the anticipation been realized. I am very proud. Proud of being able to present my friends to you, proud of the hearty reception which you have extended to them. Nothing but the most friendly feelings could have prompted you to present them, through me, with the handsome silver cup which your Chairman has so kindly and gracefully bestowed upon me. Thank you! Thank you a thousand times for your kindness! The cup will always serve as a material reminder of something far better, namely, your wonderful hospitality which could have been prompted only by the most brotherly feelings.

It is obvious that visits of this kind must be mutually beneficial. We shall be brought closer and closer together as we realize that our objectives

[1] Presented at the banquet at the Faculty Club, Ohio State University, during the tour of the British ceramists in America.

[2] Honorary Secretary, Ceramic Society of England.

are the same, that we are harassed by the same difficulties, and heartened by the same successes. The visits we pay to one another's countries are all to the good. We lose that Chinese cast of mind, that stupid contempt for everything outside the walls of our celestial empire which is only a consequence of our ignorance. We gain by acquiring new associations. We doubt where we formerly dogmatized, and we tolerate where we formerly execrated. We learn not to confound that which is local and temporary for that which is general and universal.

Each of our Societies professes "mutual aid" amongst its members. It is my fervent hope that we can have "mutual aid" of a still higher degree by bringing our respective Societies into closer touch with one another. Take two illustrations. We each prepare separate abstracts of foreign literature. What an appalling waste of energy. Surely we can effect a fifty per cent saving in the cost of preparation by arranging a mutual scheme where one set serves both Societies. Then, again, next year we hold a bicentenary celebration of Josiah Wedgwood at Stoke-on-Trent. My own view is that the work of Josiah Wedgwood has been a direct or indirect stimulus as much to you as it has been to the Staffordshire potters. We therefore invite you to help us next year to honor his memory.

Most of our work has to do with clays, and clays are very peculiar things. Like human beings, in order to get the best out of them, they must be humoured. Some require one treatment, others, another treatment. Some want forcing, some persuading. I do not know anything which so well illustrates the inexorable law of the cussedness of inanimate objects exemplified by the familiar law that bread always falls buttered side down.

May I digress by telling you how a friend of mine had the boldness to doubt the validity of this law, and how, ultimately, he was strengthened in his belief in the truth of the law. The subject of his research was "Does bread always fall buttered side down?" He first tried to see if the bread gets a special tilt in starting its descent. He devised a machine which tossed the bread in the air without bias, and he found that in the laboratory the bread fell on the wooden floor only fifty-fifty buttered side down and up, just as we are told is the case with a tossed penny falling fifty-fifty heads and tails. The inventor was proud of his machine. One day, at afternoon tea in the drawing-room, he was boasting about it to a friend. He sent for the machine and, to his confusion, he found that on the drawing-room carpeted floor, seventy per cent of the falls were buttered side down. He tried the machine on his wife's silk dress and observed that 99 per cent of the falls were buttered side down. Ultimately he was able to establish the rule that buttered bread always falls in such a way that it can do most damage. Most of us in our work on clays could give examples of the working of the law of the cussedness of inanimate objects. Thus

we are told that the pesky, green spots on sanitary ware always appear in the most prominent places.

In Great Britain, a few years back, we had to plead for a place for research in the industry, but I think that I am safe in saying that with some branches of the industry we no longer have to do that. The importance and function of research has been recognized. In England we have not the elaborate establishments which you possess. Research workers in the old days had to improvise apparatus from a few barrel hoops, the bones of an umbrella, a piece of gas piping, and a soap box. Well, they got results which do not compare unfavorably with those obtained to-day with x thousand dollar machines.

I have been very pleased to see here the principles of mass production applied to research. The work requires no encomiums from me. I am overwhelmed with admiration of the pluck and purse which enable this to be done. You have great opportunities, and I am sure that you, we, and all the world will benefit by your great conceptions. I have nothing but praise to offer.

Will you now permit me to find fault not with you but with ourselves? I do not know you well enough to be able to say whether my remarks are applicable or not.

I think we are on the wrong tack when we attempt to dominate research by the get-results-quick policy. Research then comes to be a six-hours-a-day-job and very shortly we may see notices in our laboratories something like this:

Investigators Are Expected to Prepare Two Feet of Reports per Month

You will remember Bacon claimed that anyone could make discoveries in science; the discoveries were to be made by method and not by men. Bacon signally failed in the practice of his own precepts, but I think some of our researchers are working on Baconian lines. If so, someone will soon be inventing a machine for this type of researching.

The research associations, however, have an important work to do and I think they do it well. They do illustrate what can be done by team work and the sub-division of labor; but, by neglecting what I may call the free-rovers, I believe that there is the danger that we can be associated to the death—of the individual. Does the history of the world's progress support the procedure? The general tendency of Associations is to weaken the individual while the whole is strengthened.

Suppose there had been a research association in Lavoisier's time, when it was firmly believed that coal burns because it loses phlogiston, that a metal oxidizes because it loses phlogiston, and that a metal oxide is converted into the metal because it combines with phlogiston. Suppose Lavoisier had applied to the research association for a grant to investigate

the assumption that the phlogiston theory was utterly and hopelessly wrong. His application would have been turned down as a pure waste of time and money; and he would have been dubbed an absurd crank, a heterodox dreamer. Really, we are no more sure that we are right to-day than the old phlogistians were sure that they were right. After working for years as a foolish enthusiast, Lavoisier formed a minority of one; but he soon had the chemical world at his feet.

We are not going to progress very far by stewing and roasting, boiling, and frying the same old ideas. Otherwise expressed, while we must have a thorough knowledge of the operations in our factories, and of the behavior of our materials in use, my remarks are intended to plead for a small department of heterodoxy from which we expect nothing. The purpose of this department is to try out ideas which, from some points of view, may appear to be the rankest heresy.

There is no question that generally it has been individual men who have done the bigger business of science and of the world. Research associations are all to the good, but a free-rover, like the venerable Lavoisier, or our own J. J. Thomson, is worth them all. I agree heartily with those who believe that we are fortunate in having men who are so unsocial as to think apart, drawing inspiration from the dead past, the living present, and the awakening dawn whispering of the future.

PAPERS AND DISCUSSIONS

REPORT[1] OF THE ENAMEL DIVISION STANDARDS COMMITTEE, 1929

Introduction

An effort has been made to bring to a conclusion as much as possible of the work that has been under way for the past few years.

The Committee held a meeting in Washington, D. C., December 4, 1928, going over the several problems under consideration. The amount of experimental work done has been more extensive than in the past. As a whole it is probable that the year's work has been more satisfactory than that of any previous year.

In presenting the results, a new grouping of subjects is being used. All matters having to do with the properties of enamel slips whether with regard to fundamental principles or control tests, are being presented together. The same applies to the properties of enamel at elevated temperatures. Two tests previously on record as tentative are being revised and another test, following three years study, is being recommended as tentative.

Item 1: Properties of Enamel Slips

It is the opinion of the Committee that Harrison's modification of the Bingham plastometer[2] affords the most reliable fundamental data regarding the properties of enamel slips. It is thought that the Plastometer Method, with a given enamel, for a given class of work, defines the characteristics for a given type of ware. It is realized, however, that there are as yet some objections to it as a routine shop-control method. It is quite probable that the more practical shop tests mentioned below can be so correlated with the plastometer test that the latter may take the place of a standard of reference. More work is ahead to determine this point.

The Plate Pick-up Test discussed in the Report of last year[3] and a modification of this in which the test piece takes the form of a hollow cylinder with an area of 1 sq. ft.[4] are recognized as very useful schemes.

The hollow cylinder one square foot in area, presenting two square feet of draining surface, is made by cutting out a piece of steel 9 by 16 inches which is rolled and welded into a cylinder 9 inches high. It is then given a ground coat and burned. In making the test the weighed cylinder is dipped into the enamel, brought out, and allowed to drain in an upright

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[1] Received July 25, 1929.

[2] Bur. Stand., *Tech. Paper*, No. 356.

[3] *Bull. Amer. Ceram. Soc.*, **7** [12], 356 (1928).

[4] *Amer. Enameler*, **1** [5], 5–6 (1928).

position. Immediately after draining has ceased the cylinder is weighed and the amount of enamel picked up by the two square feet is determined.

The Plate and Cylinder Methods need further study before either can be recommended as tentative. It is agreed that the surface of the test piece in either case should be coated with ground coat to assure uniform surface condition. Some prefer to determine the wet weight of the enamel picked up, some the dry weight. Which is more useful is yet to be settled. If the wet weight is to be used the maximum allowable interval between cessation of drain and time of weighing should be determined.

The determination of the gravity of a given slip is also recognized as a valuable method of control. It is not difficult for a given plant to work out a method most suited to its own condition. It is probable that the accuracy should involve the second decimal. The method presented last year is recommended as satisfactory.[5] Another scheme, presented as Appendix 1 of this Report, is also reliable.

The effect of fineness, materials in solution in the mill liquor, particularly as effected by the age of enamel, and several other factors, cannot be overlooked as general principles. What the proper conditions in a given case may be must be determined locally. Some enamels seem to work much better when well aged; others are better when used fresh. The careful use of any of the control methods under consideration should be of value in studying these points.

Item 2: Opacity

The reflection gage mentioned in the 1926–27 Report of the Committee[6] has been used by one party in studying the opacity of white enamel as effected by variations in thickness of application of a given enamel, and also in comparing various opacifiers in enamel coats of known thickness. There seems to be a definite relation between thickness of a given enamel and opacity as indicated by this device and the relative effect of variations in nature or amount of opacifier in enamel coats of known thickness seems to be capable of approximate evaluation.

These preliminary experiences led the Committee to recommend a wider use of this device along the lines mentioned.

Item 3: Enamel Raw Materials

Through the kindness of the Pennsylvania Salt Mfg. Co. the Committee is able to present as Appendix 2 a method for the analysis of cryolite that should be useful to those who analyze this material.

Last year[7] attention was called to different methods of expressing fine-

[5] *Bull. Amer. Ceram. Soc.*, **7** [12], 356 (1928).
[6] *Ibid.*, **6** [9], 260 (1927).
[7] *Ibid.*, **7** [12], 347 (1928).

ness of raw materials, particularly feldspar. Preliminary effort has been made to investigate this problem. There is nothing definite to recommend but there will be found as Appendix 3 a summary of the information obtained.

Item 4: Fineness of Wet Milled Enamel[8]

A thorough study of all available data on the subject has led to the recommendation of several modifications of the tentative method as follows:

(1) Instead of 100-gram sample, the sample used shall be that containing 100 grams of frit. The correct sample for each mill charge will, therefore, be the number of grams corresponding to the total mill charge, including water, for 100 pounds of frit. For example, a sheet iron ground with Mill Charge, No. 1 would call for a sample weighing 148 grams. In like manner, a cast-iron enamel with Mill Charge, No. 2 would necessitate a 144-gram sample.

Mill charge No. 1	Lbs.
Frit	100
Clay	6
Silica	2
Water	40
Total	148

Mill charge No. 2	Lbs.
Frit	100
Clay	4
Opacifier	6
Color	4
Water	30
Total	144

(2) The screens used shall be from the United States Sieve Series as given in Bureau of Standards Circular Letter, LC 74, "Standard Specifications for Sieves, Standard Sieve Series."

(3) In view of the fact that some enamels are milled so coarse as to leave a very large residue on a No. 200 sieve while others are milled so fine as to leave but a very small residue, a No. 100 sieve (opening of 0.0059 in.) shall be used for coarse enamels leaving over 25 g. residue on a No. 200; and a No. 325 (opening of 0.0017 in.) shall be used for fine enamels leaving less than 1 g. of residue on a No. 200. The No. 200 shall be used for the range of fineness leaving residue of from 1 to 25 grams on that sieve. The record of fineness shall contain a statement of the number of screen used.

(4) Modifications of the screen test such as the Cone Screen Test[9] and the measuring of the sample and residue by volume[10] are recognized as useful local shop control tests but in their present forms not capable of accurate standardization.

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[8] "Tentative Method for Fineness of Wet Milled Enamel," *Bull. Amer. Ceram. Soc.*, **6** [9], 263 (1927); "Comparative Study of Sieve and Settling Tests for Fineness of Milled Enamel," *ibid.*, p. 270; "Fineness of Wet Milled Enamel," *Jour. Amer. Ceram. Soc.*, **11** [6], 466 (1928); "Notes on the Sieve and Settling Tests for Fineness of Enamel," *Bull. Amer. Ceram. Soc.*, **7** [12], 353 (1928).

[9] *Bull. Amer. Ceram. Soc.*, **7** [12], 352 (1928).

[10] *Amer. Enameler*, **1** [5], 4 (1928); *Ceram. Ind.*, p. 574 (1928).

(5) The settling test[11] is recognized as being based on sound principles but has certain objections yet to be overcome that make it inadvisable to consider it for a possible standard method at present.

(6) In so far as possible, those using tests mentioned in paragraphs 4 and 5 should establish the relation between the results by those methods and those obtained by the screen test, to make possible the interchange of information in terms of the screen test.

(7) The test in the following modified form is recommended as tentative for the present year.

Tentative Method for Fineness of Wet Milled Enamel

Sample The enamel to be tested shall be stirred thoroughly to produce uniformity. A sample containing 100 grams of frit shall be weighed. This in grams corresponds to the total mill charge, including water, for 100 pounds of frit.

Sieves A No. 40 protection sieve shall be placed above the testing sieve. The testing sieve shall be either a No. 100, 200, or 325, depending on the fineness of the enamel being tested. If, on a trial run the residue retained on a No. 200 sieve as testing sieve shall be over 25 grams, a No. 100 shall be used; if the trial residue on a No. 200 is less than one gram a No. 325 shall be used; if the residue on a No. 200 is within the range of 1 to 25 grams, that sieve shall be used. The above sieve numbers refer to the United States Standard Sieve Series.

Testing The weighed sample shall be poured onto the upper (protection) screen and carefully washed through the two screens until no enamel can be detected in the washings. Nothing other than coarse, unground particles shall be retained on the protection screen. The lower (test) screen with its residue shall be thoroughly dried until the residue thereon easily moves about as a dry powder when the sieve is shaken. The sieve shall be tapped gently until less than 0.1 gram passes through on a minute's tapping.

Weighing The residue shall be transferred to a balance and weighed to the nearest 0.1 gram. The weight thus determined shall be taken as the index of fineness of the enamel in terms of the number of testing screen used.

Item 5: Properties of Enamel at Elevated Temperatures[12]

In previous Reports, the Committee has made no attempt to cover the properties of enamel at elevated temperatures other than as revealed by

[11] *Bull. Amer. Ceram. Soc.*, **6** [9], 270 (1927).

[12] "Tentative Method for Deformation Temperature of Enamel," *Bull. Amer. Ceram. Soc.*, **6** [9], 262 (1927); "Accuracy of the Cone Deformation Temperature Test as Applied to Enamels," *ibid.*, p. 264; "Notes on Tentative Method for Deformation Temperature of Enamel," *ibid.*, **7** [12], 355 (1928).

the Cone Deformation Test. It is known that other methods are in use and the Committee decided to extend its efforts and include as much as possible along new lines. It so happens that those working with the new methods are not in a position to make any statements with regard thereto, so all that we are able to do is to recommend certain modifications of the Tentative Deformation Test and to urge that attention be given to other methods of studying the properties of enamel at elevated temperatures.

It is recommended, therefore, that (1) four cones, two from each of two enamels, may be tested at a given time if mounted as shown in Fig. 2, of the Report[13] for 1927–28; (2) time be reckoned from the instant that the furnace recovers to 800°F after the drop caused by the introduction of the cones; (3) the rate of heating originally specified[13] be retained; (4) with the above modifications the Tentative Method be modified to read as follows. (See Fig. 1 (this Report).)

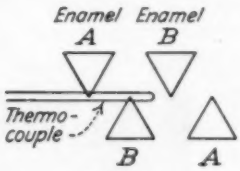

FIG. 1.

Tentative Method for Deformation Temperature of Enamel

This method is applicable to frits and milled enamel.

(1) Preparation of Sample A representative sample of frit or milled enamel shall be thoroughly dried and ground in a porcelain pebble mill to pass a 150-mesh sieve.

(2) Test Pieces The test pieces shall be the size and shape of pyrometric cones: tetrahedra $^5/_8$ inch along the edge of the base and $2^1/_2$ inches high. They shall be molded from a mixture of the powdered enamel and water with enough organic binder to produce the necessary plasticity and cohesion. The test pieces shall be thoroughly dried upon removal from the molds.

(3) Mounting The test pieces shall be mounted on a plaque of asbestos board or strip of steel which has been coated with enamel. The base of the test pieces shall be imbedded in a plastic mixture such as sand, clay, and water and their troweled faces shall make an angle of 82° with the plaque. One or two pairs of test pieces from one or two enamels shall be placed on a given plaque in the manner shown in Fig. 1, permitting the end of the thermocouple to be equidistant from the tips of each pair of test pieces without being touched thereby during deformation. The mounting shall be thoroughly dried before being placed in the furnace.

(4) Furnace The furnace shall be one which shall give a definitely oxidizing atmosphere. It shall be subject to accurate temperature control through the range 800 to 1600°F. It shall be equipped with a pyrometer, the thermocouple of which shall terminate near

[13] *Bull. Amer. Ceram. Soc.*, **6** [7], 263 (1927).

the center of the horizontal plane of the furnace and one inch or farther below the top. The pyrometer shall be of such type as to afford an accuracy of ±10°F, with proper corrections for cold end temperature.

(5) Placing of Test Pieces in Furnace The mounting shall be placed in the furnace in such a manner that the tips of the test pieces from each enamel shall be 1/2 inch above the center of the thermocouple and horizontally equidistant therefrom.

(6) Rate of Heating The furnace shall be at or below 800°F when the test pieces are placed therein. The rate of heating shall be the following:

	°F
Start	800
10 min.	1020
20 "	1150
30 "	1260
40 "	1370

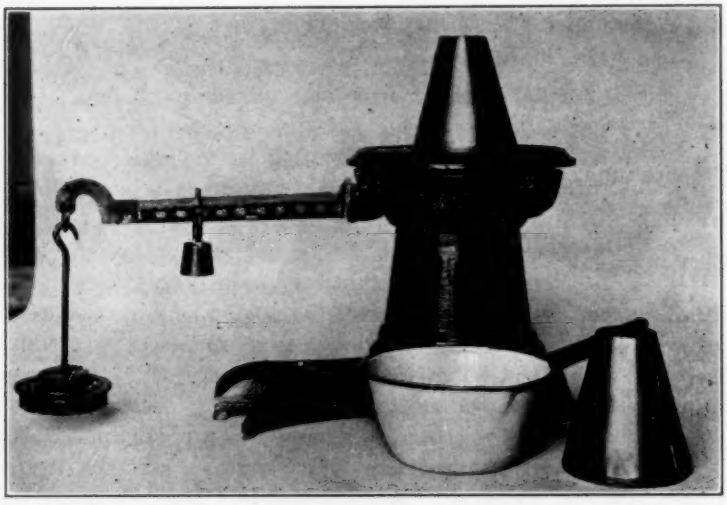

FIG. 2.

(7) Observations The "starting time" shall be the instant that the pyrometer indicates a temperature of 800°F on recovering from the drop in temperature caused by the introduction of the test pieces. Each test piece shall be observed separately with reference to the temperature of initial bending of the tip and final bending of the tip to the level of the base. The first observations shall be averaged as the "starting temperature" and the final as the "deformation temperature." The difference between the two shall be taken as the "deformation range." Two or more closely checking runs shall be averaged for final results.

Item 6: Pickle Room Control

The Committee recognizes as of satisfactory accuracy the test pills on the market for the determination of the strength of acid and alkali baths; also the amount of iron in acid baths.

Titration methods are capable of greater accuracy and are to be recommended for those plants having the necessary facilities. A plant chemist can devise a method, the details of which most fully meet the needs of a particular shop. As an example of such method the one given by Sweely[14] as well as the one in the Committee Report[15] for 1927–28 is suggested.

Item 7: Bending Test for Sheet Iron Enamel[16]

The Titanium Alloy Mfg. Company furnished to several parties machines made in accordance with the drawing shown as Fig. 7 of last year's Report.[17] These machines made possible a coöperative test to determine whether or not given enamels tested on several machines by a uniform method would give consistent results. Test strips of metal from a given shop were distributed among five enameling plants, each enameling the strips according to instructions furnished by the Committee. These enameled samples were submitted to the Bureau of Standards who distributed those from each plant among five parties having testing machines. In this manner each of the five testing parties received strips from each of the five enameling plants. An effort was made to include a variety as to type of shop and laboratory making and testing samples.

In making the tests the load was advanced at the rate of 0.02 inch every five minutes. The first crack to extend entirely across the piece was taken to indicate failure. The cracks were detected by means of a smear of lamp-black in vaseline.

DEFLECTION TO PRODUCE FIRST CRACK CLEAR ACROSS PIECE

Plant ⟶ / Test party	0	1	2	3	4	Average
A	0.35 in.	0.49 in.	0.42 in.	0.50 in.	0.38 in.	0.428 in.
B	0.38	0.50	0.47	0.42	0.38	0.430
C	0.36	0.53	0.45	0.52	0.34	0.420
D	0.34	0.45	0.42	0.45	0.40	0.412
E	0.35	0.51	0.44	0.43	0.38	0.422
Average	0.356	0.496	0.440	0.464	0.376	0.422
Deviation from average						
Plus	0.024	0.034	0.030	0.056	0.024	0.008
Minus	0.016	0.046	0.020	0.044	0.036	0.010

[14] *Jour. Amer. Ceram. Soc.*, **9** [9], 590 (1926).

[15] *Bull. Amer. Ceram. Soc.*, **7** [12], 350 (1928).

[16] "Investigation of the Lindemann-Danielson Cross-Bending Test for Sheet Iron Enamel," *Bull. Amer. Ceram. Soc.*, **6** [9], 277 (1927). "Further Studies of the Lindemann-Danielson Cross-Bending Machine," *ibid.*, **7** [12], 360 (1928).

[17] *Ibid.*, p. 362.

The results of the tests have been carefully studied and reduced to the table. (See page 279.) The numbers refer to the several plants enameling the strips while the letters designate the parties making the test.

Although there are some discrepancies in the results of the several tests, the Committee feels that there is a sufficient agreement as to values for each enamel and average results for each tester to indicate a definite usefulness of the method. In addition to the mere data in line with the purpose of the coöperative test, several considerations of value have been obtained and these will be found in Appendix 4 herewith.

Several parties not included in the test have had considerable experience with the machine. The Committee has corresponded with them and a study of the replies to certain questions are taken into consideration in connection with the recommendations being made.

In view of all of the facts at the disposal of the Committee many of which are brought out in Appendix 4, it is recommended that the test be approved as "Tentative" in the following form:

Tentative Method for Determining the Resistance of Sheet Steel Enamel to Deflection

Testing Machine The machine used in the test shall embody the essential details of that shown as Fig. 7, Report[18] of the Enamel Division Standards Committee 1927–28.

Preparation of Test Pieces The metal base shall be strips from 22-gage enameling stock, cut 2 in. wide and 12 in. long. For convenience in handling during processing a $^1/_4$-in. hole may be punched near one end of the strip.

The numbered strips shall be carefully pickled and after drying weighed to the nearest $^1/_2$ gram. They shall be dipped in commercial ground coat, dried, burned, and weighed. Strips which do not appear to represent good local practice shall be rejected. Two coats of the enamel to be tested shall be applied. Before burning each cover coat, the edges shall be brushed back $^1/_8$ in. to prevent the forming of a bead. Pieces showing excessive warpage or having burning tool marks near the center shall be rejected. After enameling, the strips shall again be weighed to the nearest $^1/_2$ gram and by subtracting the weight in ground coat the weight of the cover enamel is determined. For use in the test only strips bearing cover enamel within $\pm^1/_2$ gram of the amount determined by local practice shall be used.

Each shop shall determine the weight of enamel on the standard test piece corresponding to the thickness used in commercial practice. (Information now available suggests a weight range of from 7 to 10 grams as covering practice for two coats of white enamel.)

[18] *Bull. Amer. Ceram. Soc.*, **7** [12], 362 (1928).

Testing With the center roller dropped to a sufficiently low position test pieces shall be so placed in the machine that the back ends will rest against the under side of the back roller with the front ends not touching the front roller. The position of the center roller shall then be advanced till one or more of the strips just touches the under side of the front roller. The dial shall be read and this reading taken as the initial reading for the strips thus making contact. The center roller shall then be advanced at the specified rate and the dial readings taken where each of the other strips makes contact.

From the time that the first strip makes contact till the last strip has failed the center roller shall be advanced at the uniform rate of 0.02 inch every two minutes.

After the last strip has made contact the surface of each piece over the center roller shall be coated with a smear of lamp black in vaseline and just before each advance in position the surface shall be carefully rubbed with a cloth to note whether or not a crack has been produced. Care shall be taken to confine this rubbing to the area immediately over the center roller; otherwise pressure on the test pieces may affect results.

When the first significant crack appears on a given strip the dial shall be read and the value recorded as the final reading for the strip involved. (The term "significant crack" shall be taken to mean a crack extending more than half way across the test piece.)

The difference between the initial and final readings for a given strip, expressing the number of hundredths of an inch of deflection to produce failure, shall be taken as the deflection value for the piece.

Deflection Value The deflection value for a given enamel shall be the average results from not less than six individual test pieces. The record of the test shall include the average weight of the ground and cover coats.

Note: In addition to the information afforded by the deflection to produce first crack, it is of value to continue the advance of the center roller noting the behavior of the enamel under the more extreme deflection.

Item 8: Method of Expressing Enamel Compositions

It is the opinion of the Committee that as yet no method of expressing enamel compositions has been suggested which is really satisfactory in terms of the several requirements named in the Report[19] for 1927–28. Until a more satisfactory plan is arrived at, however, the Committee recommends the use of the method suggested in the last Report: (*a*) batch weight giving 100 lbs. melted weight; (*b*) a calculated melted weight totaling 100 lbs. in which those ingredients of the batch, such as borax, feldspar,

[19] *Bull. Amer. Ceram. Soc.*, **7** [12], 366 (1928).

etc., that can be broken down into simple oxides without the use of additional oxygen, are so computed; while materials such as cryolite and fluorspar are retained as such in the melted weight expression.

In expressing the compositions of raw and melted weights it is not necessary to outline in detail the distribution of the oxides from the individual materials as in the above-mentioned Report; this was given to illustrate the method.

Respectfully submitted,

E. P. Poste, *Chairman*
R. D. Cooke
W. N. Harrison
B. A. Rice

APPENDIX 1

Method for Determining Gravity of Enamel Slip

A new scheme for determining the gravity of enamel slip has been submitted to the Committee and seems to have sufficient merit to be placed on record.

The container for the slip is in the form of a truncated cone, open at the top. It is made of copper. This holds exactly one pound of water at room temperature.

The scale used is a standard design (Howe Catalog, No. 601) with beam graduated into hundredths of a pound. A tare weight exactly balancing the empty flask is used.

Filling the flask with enamel level full and placing it on the scale, the weight in pounds expressed decimally is the gravity. With a one pound weight on the hook, the reading of the beam plus one is the slip gravity.

The apparatus with an extra flask and pan used for filling is shown in Fig. 2.

The user of this device, who is very enthusiastic as to its value, claims that it "has the advantage of being direct reading without the use of small weights which sometimes get lost, uses a smaller sample, and the shape of the flask permits inspection of the entire inside to be sure that it is clean." The implied comparison refers to the device using a 1000-cc. flask described in the Report of last year.[20]

APPENDIX 2

Total Analysis of Cryolite

Fluorine Grind the sample through 200-mesh and boil one gram of this fine material for one-half hour with $1^1/_2$ g. of pure CaO, which has also been finely ground. During the boiling, stir frequently, and add water from time to time as needed, to keep the volume about constant. Cool the mixture, add 1–10 HCl a few drops at a time, and

[20] *Bull. Amer. Ceram. Soc.*, **7** [12], 358 (1928).

water, just sufficient to discharge the color of phenolphthalein. When a point has been reached that the color does not return in fifteen minutes add one more drop of the dilute acid and allow to digest in the cold for several hours. During this neutralization of the excess CaO, frequent stirring is needed and the lower the total acidity is kept, the less possibility there will be of the results being low. Care must be taken, however, to insure that the neutralization is complete.

The mixture should now be very slightly acid, and a drop of NH_4OH is added to bring about the precipitation of the alumina and iron hydroxide. This is done in the cold, the mixture is allowed to settle, and is then washed by decantation with several changes of water. The precipitate is then filtered, dried, and ignited to constant weight. The sample now consists of calcium fluoride, silica, and the oxides of iron and aluminum. The calcium fluoride may be determined by difference. The conversion factor, $CaF_2 \div F$, is 2.05447. A check on this value may be made by transferring the material to a platinum crucible, adding a few drops of dilute H_2SO_4, and igniting till the fumes cease. Weigh and repeat the process if necessary to convert all the fluoride to calcium sulphate. The gain in weight, multiplied by 0.6552 gives the fluorine value again.

Sodium To the filtrate from the above determination add ammonium oxalate, to precipitate all the lime, allow to settle, and filter. Acidify the filtrate with a few drops of HCl to convert all the sodium to chloride, and evaporate to dryness. Ignite gently to expel all ammonium salts, and weigh as sodium chloride.

Alumina Ignite a one-gram sample of the finely ground material with five or six grams of sodium bisulphate for thirty minutes. Dissolve in water and filter off any silica remaining undissolved. Precipitate the iron and alumina by adding ammonia water, wash very thoroughly with hot water, after filtering; then dry, ignite to constant weight and weigh. Treat with hydrofluoric acid and a few drops of H_2SO_4; ignite, and weigh. Loss is silica, to which value is added that of the silica remaining on the filter from the bisulphate fusion. The sample now consists of alumina and iron oxide.

Ferric Oxide In fairly pure cryolite a large sample is needed. Forty or fifty grams of the finely ground material are placed in a covered beaker and boiled with 300 cc. of 10% HCl. Filter, wash, and titrate the filtrate with standard potassium dichromate according to the usual procedure.

APPENDIX 3

Fineness of Feldspar

The Committee has carried on a considerable correspondence with various feldspar producers and has interviewed several other parties with

reference to methods of determining and expressing the fineness of feldspar. Obviously the information obtained would apply to other materials such as silica.

The first feldspar grinder approached gave the following as the method in determining fineness:

A 100-gram sample is weighed and transferred to a No. 325 sieve. The fines are washed through the sieve by immersing it partially in a large pan of water and lifting to drain, and repeating the process until only a negligible quantity of material passes through the sieve. The material retained on the sieve is then dried at 110°C, and the sieve shaken further until the weight of material passing per minute is less than 0.05 gram. The material retained on the sieve is then weighed, and transferred to the next finest sieve of the series. The above procedure for further separation of fines is repeated and the process carried on through the remainder of the series of sieves in order, proceeding from the finer to the coarser sieves. The separations are finally expressed by subtracting in each case the weight of material retained on the next coarsest sieve of the series, since the residues on the coarser sieves are included in the weights observed.

In the case of a sample having a relatively large proportion of coarse grains, the separations on the material retained on the No. 325 sieve are made by proceeding from the coarser to the finer sieves.

In commenting on the interpretation of the fineness results this company says:

> In the case of our finer ground feldspars, that is, 140-mesh or finer, we maintain a definite limit of residue for each grade. The 140-mesh material should not show a total residue of over 0.1% on a No. 140 sieve, and about 0.7% on a 200 sieve. In the case of the coarser grades of feldspar, the designation is determined by the screen through which the material is passed when set at an angle of 45°. We use the designation as recommended by the screen manufacturers, that is, the average fineness as double the screen mesh used; as, for instance, 90-mesh material is passed through a 45-mesh screen at an angle of 45°.

Another leading producer of ground feldspar has suggested to the Committee that an effort be made to set up mesh classifications based on percentage through the standard 200-mesh sieve and percentage retained on the mesh designated. As to the percentage on mesh designated it is suggested that this would not exceed 1.5%. For instance, a 140-mesh grinding would be specified as from 4 to 7% on the standard 200-mesh sieve and not to exceed 1.5% on the 140-mesh sieve. It is emphasized by this producer that the method of making tests should be specified in detail to avoid wide differences in results on a given material.

To illustrate the above plan the following table is offered:

GRINDING CLASSIFICATIONS

Mesh group	Basis per cent on 200-mesh	Difference	Per cent on mesh designated	*Screen opening (inch)	*Diam. wire (inch)
240	0.00– 0.35	0.35	0.00–1.00	0.0026	0.0016
200	0.35– 1.00	0.65	0.35–1.00	0.0029	0.0021
180	1.00– 2.00	1.00	0.5 –1.00	0.0033	0.0023
160	2.00– 4.00	2.00	0.5 –1.00	0.0038	0.0025
140	4.00– 7.00	3.00	0.5 –1.00	0.0042	0.0029
120	7.00–11.00	4.00	0.3 –1.00	0.0046	0.0037
100	11.00–16.00	5.00	0.00–1.00	0.0055	0.0045
80	16.00–27.00	6.00	0.00–1.00	0.0068	0.0057
60	22.00–30.00	8.00	0.00–0.60	0.0087	0.0080
40	30.00–42.00	12.00	0.00–0.10	0.0150	0.0100
20	42.00–62.00	20.00	None	0.0328	0.0172

* 20- and 200-mesh are Standard; others from W. S. Tyler Catalog No. 53, page 48.

The method of testing used by this company is the following:

A 100-gram portion of the sample is weighed out to an accuracy of 0.1 gram. This is washed in a standard 200-mesh sieve by holding it under a small jet of water under low pressure. The contents of the sieve are then thoroughly dried on an electric hot plate and weighed on a balance to an accuracy of 0.01 gram, and the difference noted between this and the original weight. To this difference is added the weight of fine material passing the same sieve as is used again in completing the test. The dried material is then placed on the coarsest sieve and the test completed using all the sieves including that used in the washing process. In making these tests the sieve is held in one hand in a slightly inclined position so that the sample will be well distributed over the sieve, at the same time gently striking the side against the palm of the hand on the up-stroke. The operation is continued with each sieve until no appreciable screening is observed.

In discussing the problem with a third producer the thought was advanced that nothing short of a complete screen analysis could be accepted as defining the fineness of a feldspar. Shorter methods might serve as grinding controls for a given grinding method but variations in the system of grinding would so alter the fineness distribution as a whole that percentages retained on one or two screens could not safely be used as a designation of fineness.

A technical man familiar with the problem suggested the possibility of adding a 325-mesh sieve to the 200-mesh and designated mesh.

The point of view of a manufacturer of testing sieves was sought. The response took the form of the feldspar specifications recommended by a Committee on Specifications for Feldspar for White Ware presented at the Exposition of Chemical Industries some years ago. As to fineness the reading is as follows:

One hundred grams of the sample, after being dried to constant weight at 105°C, shall be tested for fineness of grain, according to the process set forth below and the residues on the various sieves shall not exceed the maximum as set forth in the following table:

Screen no.	100	140	200	270	325	Total residue
Grade 1	0.25	0.5	1.25	2.0	5.0	9%
Grade 2	0.50	1.0	2.5	4.0	6.0	14%
Grade 3	0.75	1.25	3.75	5.0	8.0	18.75

For the screen analysis, the Standard Screen Scale sieves are used, the openings increasing in the ratio of the fourth root of 2 or 1.189 as recommended in the AMERICAN CERAMIC SOCIETY, *Year Book 1922-23*, p. 36. All percentages are made on the dry basis.

Method of Making the Fineness Test

The 100 grams of dry sample shall be transferred to the sieve and over a sieve pan which fits closely enough to prevent loss of slopping. The pan shall contain sufficient water to reach within not less than $^3/_4$ in. (20 mm.) or more than $1^1/_4$ in. (31 mm.) from the pan. The sieve and pan shall be vibrated or shaken in such a manner that water in the pan is splashed on the screen from below, so as to wash the powder about and cause the material that can pass through the sieve to pass into the pan below. This treatment shall be continued until no more material can be removed.

The residue and sides of the sieve shall then be thoroughly washed with water by means of a laboratory wash bottle.

In the washing process, a fine brush may be used to break down such small aggregates as refuse to break up by washing alone.

The order of the sieves shall be as follows: Wash the sample on the 325-sieve to remove all fines, as this facilitates an accurate classification of the coarse material. The material passing this sieve may be concentrated by evaporation to dryness and weighed, or may be immediately thrown away and its amount determined by difference. The residue on the 325-mesh sieve is transferred to the 100-mesh and washed as described above. The material on the sieve is dried and weighed; the material passing the 100-mesh sieve is transferred to the 140-mesh sieve and washed, and this process continued to the 200-, 270-, and 375-mesh in order, the residues on each being dried and weighed.

With reference to method of testing, the sieve manufacturer states:

> Our experience with the use of testing sieves in measuring the fineness of materials suggests to our mind that there may be greater differences in the conclusions reached by different men on the same product than there would be in different products by the same man; therefore, it should be emphasized that certain standardized methods of testing and standard conditions of sieves should be insisted upon as well as the specified range of fineness of the product tested.

The material herein suggests definitely the need of further work on the problem of standard methods of making and interpreting tests for fineness.

APPENDIX 4

Notes on Bending Test for Sheet Iron Enamel

The subject matter in Item 7 (Bending Test for Sheet Iron Enamel) (p. 279 of this Report) includes only that bearing directly on the actual purpose of the coöperative test, "to determine whether given enamels tested on several machines by a uniform method would give consistent results." As the principal result of the test the method has been suggested for adoption as tentative. Incidental to the essential purpose several valuable observations have been made and certain features of the test suggest further study as a means of determining the correct details of method. Such considerations form the basis of this Appendix.

Before the metal strips were distributed for enameling they were weighed individually and to each enameling plant were sent strips as nearly as possible of the same weight. Upon receipt of the enameled strips at the Bureau those from a given enameling plant were weighed and from the average weight before and after enameling the average weight of enamel for each plant was determined. The initial weighing was obviously done prior to pickling so that the calculated average weight of enamel includes pickling loss, ground and white enamel. In making the bending tests the schedule for arranging the strips in the machine was such as to avoid the placing of strips from a given enameling plant at the same position in the machine during successive runs. Three points were recorded for each strip: (*a*) first crack at edge (at slight bead of heavy enamel), (*b*) first crack extending half way across piece, (*c*) first crack extending entirely across piece.

In addition to the work involved in the original tests further experimental work has been done and considerable correspondence has been carried on with users of the machine. The results of these efforts are being presented to explain certain conclusions reached in the Report and as of possible value in the further refinement of the method.

Preparation of Test Pieces

In addition to regulating the thickness of metal and amount of enamel to be applied which will be discussed later, experience with testing specimens has suggested other precautions that promote accuracy of results. In applying the ground coat it is quite common that a bead of thick enamel forms along one edge of the piece. The same is true of the white. Test pieces having a bead due to thick enamel crack prematurely at such beads and cracks starting in this manner may progress out into the enamel of normal thickness at a deflection less than that which would be required to start a crack were the bead not there. The remedy for this suggested to the Committee is to brush back the white for $^1/_8$ inch from either edge. This apparently takes care of the problem. On examining the backs of pieces that had bent

RESULTS OF BENDING TESTS

Plant Cracked / Test Party	0			1			2			3			4		
	E	½	X	E	½	X	E	½	X	E	½	X	E	½	X
A	0.33	0.34	0.35	0.42	0.46	0.49	0.40	0.41	0.42	0.46	0.47	0.50	0.37	0.37	0.38
B	0.32	0.36	0.38	0.46	0.48	0.50	0.39	0.44	0.47	0.42	0.49	0.42	0.30	0.35	0.38
C	0.30	0.34	0.36	0.46	0.49	0.53	0.39	0.40	0.45	0.43	0.48	0.52	0.27	0.30	0.34
D	0.28	0.29	0.34	0.40	0.41	0.45	0.24	0.33	0.42	0.36	0.40	0.45		0.32	0.40
E	0.34	0.34	0.35	0.43	0.47	0.51	0.41	0.44	0.44	0.40	0.41	0.43	0.36	0.37	0.38
Average	0.314	0.334	0.356	0.434	0.462	0.496	0.366	0.404	0.440	0.414	0.450	0.464	0.325	0.342	0.376

E, first crack at edge; ½, first crack half way across; X, first crack clear across.

sharply rather than gradually around the center roller it was noted that burning marks in the ground coat were the cause. To prevent premature local cracking from this cause care should be taken to avoid any break in the ground from burning tools near the center of the piece. In testing pieces that were badly warped on burning, the twisting effect produced on bending has been noted as causing a set of preliminary cracks not at right angles to the length of the strip, later crossed by the usual cracks. Obviously pieces more than slightly warped should not be used.

Rate of Bending Several rates of bending were considered by the Committee before the tests were made. The original investigation by the Committee[21] pointed out that "the deflection required to produce first cracking decreased with the increase of the rate of application of the load." The rate of one hundredth of an inch per minute was used in later work.[22] The first laboratory to make commercial use of the method uses an advance of 0.02 inch every ten minutes. The next rate reported was 0.02 inch every fifteen minutes. It was decided that the purpose of the coöperative test would be met with a rate of 0.02 inch every five minutes, thus falling within the extremes and saving considerable time over the slower rates.

Considerable thought has been given to this point. Commercial ware is subjected to two types of strain; on mounting a stove, for instance, a rather sudden deflection of the enamel on a warped piece may take place, possibly causing immediate failure; if this does not occur at once the enamel remains in a strained condition for the indefinite future and may or may not fail. Some have thought that the test should involve a very slow rate of deflection with long periods between advances to approach the strain in a commercial piece after bending. Others have felt that the test is definitely an "accelerated" test and that a rapid rate of deflection would tell as much

[21] *Bull. Amer. Ceram. Soc.*, **6** [9], 278 (1927).

[22] *Ibid.*, **6** [9], 278–80 (1927); **7** [12], 364 (1928).

as a slower as to the actual strength of the enamel. All seem to have realized that the numerical results would vary with different rates but that to be acceptable the test should give good check results at any given rate.

The rate of 0.02 in. every two minutes specified in the Tentative Method results from a study of the suggestions of several users of the machine.

Index of Failure The Committee Report of last year brought out various points of view with reference to what particular stage in the test should be taken as "failure" of the enamel.[23]

In carrying out the present tests it was decided to confine observations to the cracking of the enamel and not to include jumping. It was further decided to take the first crack clear across as the index of failure. The results presented in the body of the Report are on this basis. The additional data with reference to first crack at edge and first crack half-way across are now given.

The values for first crack clear across placed the several enamels in the following order as to decreasing strength: Plant 0, 4, 2, 3, and 1. The other observations give the same order. Certain peculiarities in the figures for individual test strips (not included in the summary of data presented) cause some lack of faith in the figures for first crack at edge, and the decision to brush back from the edges in preparing test pieces eliminates the possible use of that observation.

One observer has found merit in plotting results in terms of the number of cracks appearing with advance of center roller after first crack has appeared.[24] The Committee has had no opportunity to investigate this method. The characteristic curve shows an abrupt rise at and immediately after the first crack, followed by a less sudden rise for further advance of the roller.

The laboratory that has made the widest use of the method uses the first crack more than half-way across the piece as the index of failure. The available information suggested to the Committee that this is probably the most desirable index and it has been termed the "first significant crack." Difficulties in observation have made it hard to note the exact deflection causing first jumping.

Thickness of Enamel In the coöperative test the values for average weight of enamel from each plant and deflection to produce first crack are:

Plant	Weight of enamel (grams)	Deflection first crack (inch)
0	23.8	0.356
1	16.7	0.496
2	17.9	0.440
3	17.4	0.464
4	23.2	0.376

[23] *Bull. Amer. Ceram. Soc.*, **7** [12], 360 (1928).

[24] *Ceram. Ind.*, p. 575 (1928).

Plotting deflection against weight gives the suggestion that thickness of enamel as indicated by weight on a given area has a more definite effect on the resistance to bending than has any difference in the enamels themselves. (Fig. 3.)

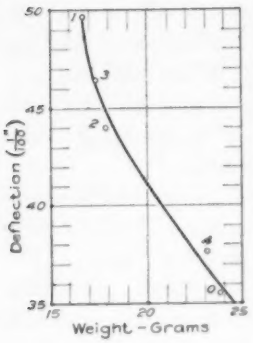

FIG. 3.

Plant	Weight	Deflection (inch)
0	23.89	0.356
1	16.70	0.496
2	17.90	0.440
3	17.40	0.464
4	23.20	0.376

This possibility seemed so striking that the Committee carried out two series of tests to throw light on the case. In the first, three sets of test pieces were made from the same enamel, the first with one, the second two, and the third three coats of white. The thickness of each strip near the center was determined with a micrometer after ground coat and each coat of white. Each strip was also weighed after each coat. The weights were found to be directly proportional to thickness, indicating no serious error in determination. The opacity of each piece was also noted by means of the deflection gage. The strips were tested in the machine, failure being taken as first crack clear across. The data are

Number of coats	Weight of white (grams)	Thickness of white (inch)	Reflection factor (%)	Failure (inch)
1	5.0	0.0059	56	0.62
2	11.0	0.0123	71	0.33
3	22.3	0.0229	79	0.20

These figures plotted as deflection and reflection against thickness give very interesting curves. Fig. 4. The idea that these two properties are functions of thickness is nothing new but the possibility of a rather definite quantitative relation determined by actual test seemed to be worth consideration.

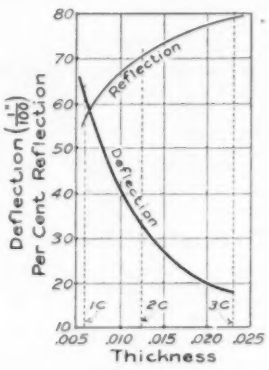

FIG. 4.

No. Coats	Thickness (inch)	Deflection (inch)	Reflection (%)
1	0.0059	0.62	56
2	0.0123	0.33	71
3	0.0229	0.20	79

The coöperative tests involved five enamels each at a different thickness. The above tabulated comparison included samples of one enamel at varying thickness. The next step was to note the effect of varying thickness on three enamels of different types.

Three frits of quite different nature were used in making up three enamels using the same mill charge. One frit was that used for white stove parts; another was a frit made by re-smelting spray-booth residue; while the third was a rather transparent glaze used for making grained ware. It might well be expected

that these frits would display different properties when processed in a given fashion.

One-, two-, and three-coat samples were prepared, micrometered after each coat, and tested in the bending machine. The results are as follows:

Enamel	No. coats	Thickness (inch)	Deflection (inch)
A	1	0.0089	0.66
	2	0.0142	0.45
	3	0.0182	0.35
B	1	0.0091	0.79
	2	0.0150	0.57
	3	0.0177	0.48
C	1	0.0090	0.69
	2	0.0154	0.46
	3	0.0202	0.34

The plotting of these values gives a distinct curve for each enamel suggesting that the test does definitely distinguish between the individual frits. (Fig. 5.)

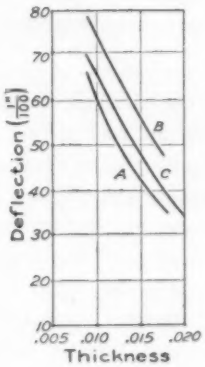

FIG. 5.

From this it must be concluded that the five enamels tested in the coöperative test were of approximately the same fundamental strength as evidenced by the smooth curve approached when the deflection values were plotted against weight of enamel.

These several observations point definitely to the fact that if enamels are to be compared by the test their thickness must be taken into account. Three general possibilities come to mind: (*a*) actually measure the thickness of the enamel with a micrometer or accurately weigh the enamel on the test strips and plot results of bending test against thickness or weight of enamel and from the curve arrive at the deflection to produce failure at a definite thickness; (*b*) make up a relatively large number of test pieces weighing the enamel on each and selecting those which come within a certain specified limited range of weight for use in the test; (*c*) determine from careful observation the weight of enamel on the test piece which represents commercial practice for the enamel involved and select from several test pieces only those which come within a certain specified range with reference to the chosen weight for the given enamel. A slight modification of the third method has been suggested as follows: "only strips bearing such an amount of enamel that the heaviest is not more than $x\%$ greater than the lightest shall be used."

Enamel	No. Coats	Thickness (inches)	Deflection (inches)
A	1	0.0089	0.66
	2	0.0142	0.45
	3	0.0182	0.35
B	1	0.0091	0.79
	2	0.0150	0.57
	3	0.0177	0.48
C	1	0.0090	0.69
	2	0.0154	0.46
	3	0.0202	0.34

Of the two parties having the widest experience with the test, one uses strips bearing 8 grams of white, the other 9 grams. In each case the strips are 2 by 12 inches in dimension.

After a study of the several possibilities the Committee decided on the details of control specified in the statement of the proposed Tentative Method.

Thickness of Metal The possible effect of variations in thickness of metal has not been overlooked. No definite information is at hand, however. In one series of tests strips coated with a given enamel were known to vary in thickness through a range of about 10% but no relation between this variation and bending test results could be noted. It is unfortunate that the Committee has not found time to cover this phase of the problem. It is assumed that a uniform thickness of metal should be used. Hence 22-gage has been suggested for use.

Selection of Samples This consideration appears toward the end that the facts presented previously might be in mind in connection therewith. The selection of the samples is a matter of fundamental importance. There are two possible points of view with reference to the test as a whole which have been expressed to the Committee. Some think of the test as a possible method for determining the resistance of a given enamel to deflection under accurately controlled conditions, getting as far as possible away from any variations which might be characteristic of shop procedure. Others think of the test as a method of indicating what is to be expected of commercial ware as produced in a given shop. Both are within reason. The first thought has a definite standard test in mind; the second merely a local control test. It is rather the purpose of the Committee to treat it as of the former class, leaving the individual user to take such liberties with it as may best suit his purpose.

In the coöperative tests ten pieces of a given enamel were tested by each party. In the later work reported in these notes five pieces were used in each case. In both certain individual pieces failed at values so far from the average that they were clearly not representative of the lot. In most such cases the strips were warped, well out of range in deviation from the average thickness of metal or weight of enamel or otherwise out of line.

Two methods of choosing samples have been considered: the use of a small number of carefully selected pieces or the use of a larger number of unselected pieces. In the first case the results would be expressed as the numerical average, while in the other the values would be plotted and interpreted by the "statistical" method. The second involves the throwing out of the "freak" test pieces as indicated by the results of the test as compared with the more careful initial selection of the samples. At best the test is long. To use the statistical method at least fifty individual

values are needed for a given case. These facts have led to the suggestion that the samples be few in number and carefully selected.

Value of Test In addition to the good that may come from numerical results in terms of deflection to produce a certain type of failure, many who have used the test for some time feel that through it a great deal may be learned as to relation between ground and cover coats. The fact that a number of the more progressive companies are using the test in its present form is significant. Among the endorsements on file the following four are given:

(1) I believe that the test has merit and I can state definitely that the machine has had a valuable place in our researches. It is my impression that at several industrial enameling plants where the machine has been used considerable value is attached to it. I would say that you would be justified in recommending the method as a tentative test.

(2) In reply to your question whether there is enough merit in this bending test to warrant its use as a standard method, we can only say that it is the only method we know of at present for properly comparing sheet steel enamels in regard to strength.

(3) We feel that this test is well worth while and have made it standard practice in our enamel controlling system.

(4) I think that the merits in this test and the benefits derived by each individual in testing his own enamel for flexibility more than warrant the extra work of testing.

Other expressions of similar nature have led the Committee to feel that in his own way each of quite a number of parties has worked out the details of the method in such a manner as to be very useful. If, from these experiences, a satisfactory standard method can be evolved the good of the industry will have been well served.

ACTIVITIES OF THE SOCIETY

ACTIVITIES AND MORE ACTIVITIES

The AMERICAN CERAMIC SOCIETY is going forward through activities and accomplishments. This is natural. This SOCIETY can not be static. Being coöperative, with not a thing in the world to sell; just simply creating and collecting and systematizing information; financial profit accruing only to those who use this information, why should it not go ahead, and rapidly so.

If the ceramic industries are not holding their own is it not possibly due to not making this, their SOCIETY, all that it should be?

Now for those activities, the following are definitely scheduled.

(1) September 10. Columbus. Meeting of those interested in associated promotion of ceramic research by states.

(2) September 24–25. Columbus, Deshler Wallick Hotel. Meeting of American Refractories Institute and the Refractories Division of the AMERICAN CERAMIC SOCIETY. Four technical sessions.

(3) February 16–20, 1930. Toronto, Ontario. Royal York Hotel. Annual Meeting of the AMERICAN CERAMIC SOCIETY. Seven Divisions. Seven simultaneous meetings.

(4) May 18–24, 1930. Stoke-on-Trent, England. Celebrating bicentenary anniversary of birth of Josiah Wedgwood. Auspices of the Ceramic Society of England.

To all of these you are invited and will be doubly welcomed.

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Hewitt Wilson, University of Washington, Seattle, Wash.
G. R. Shelton, N. C. State College, Raleigh, N. C.

NEW MEMBERS RECEIVED FROM JULY 1 TO AUGUST 1

PERSONAL

Ernest R. Brauner, 949 N. Karlov Ave., Chicago, Ill., Ceramic Engineer, Federal Electric Sign Co.
George S. Good, Jr., Vice-President, Patton Clay Mfg. Co., Patton, Pa.
George W. Kyle, 3117½ W. Third St., Los Angeles, Calif., Sales Representative, L. H. Butcher Co., 2034 Bay St.
Jaroslav J. Marek, 2440 S. 50th Ave., Cicero, Ill., Ceramist, Coe Dental Laboratories, 6033 S. Wentworth Ave., Chicago, Ill.
E. S. McGuire, Research Dept., General Refractories Co., Box 935, Baltimore, Md.
John Sawyer, 145 N. Gates St., Los Angeles, Calif.
Jane Uhl, Uhl Pottery Co., Evansville, Ind., Designer.

STUDENT

Carl E. Curtis, Univ. of Washington, Seattle, Wash.
W. Wurth Kriegel, Univ. of Washington, Seattle, Wash.
John Moser, Ohio State Univ., Columbus, Ohio.

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PERSONAL		STUDENT	
A. Malinovszky	1	W. F. Copp	1
Fred H. Robertson	1	Hewitt Wilson	2
K. B. Strong	1		
L. J. Trostel	1	Total	3
W. W. Wilkins	3	Grand Total	10
Total	7		

ROSTER CHANGES IN AUGUST

PERSONAL CHANGES*

Black, Thompson W., 210 Parkmount Road, Toronto, Ont., Canada. (Ceramic Products, Ltd., 911 St. Clarens Ave.)
Burr, Marion K., The Charles Taylor Sons Co., McCall, Ky. (Jamestown, Ohio.)
Carter, C. C., 528 Abington Ave., Zanesville, Ohio. (686 E. Second St., Chillicothe, Ohio.)

* Addresses within the parentheses ( ) represent the old address.

Ebright, H. E., 1429 Cohassett Ave., Cleveland, Ohio. (1607 Parkwood Rd.)
Grant, W. H., North American Refractories Co., St. Marys, Pa. (Kane Brick & Tile Co.)
Harrison, H. C., Roseville, Ohio. (631 N. Main St., Uhrichsville, Ohio.)
Hosmer, Madeline F., Severna Park, Md. (208 Geneva St., Decatur, Ga.)
Miner, Joshua L., The Atlas Lumnite Cement Co., 25 Broadway, New York, N. Y. (814 Second Place, Plainfield, N. J.)
Ockerman, Elmer H., 3904 W. 54th St., Los Angeles, Calif. (2626 Manhattan Place.)
Pearce, R. Melville, 36 Elder St., Schenectady, N. Y., General Electric Co. (250 12th Ave., Columbus, Ohio.)
Spiker, John E., 1347 Portia St., Los Angeles, Calif. (1120 2nd Ave., Salt Lake City, Utah.)
Swain, Stephen M., Kier Fire Brick Co., Salina, Pa. (Mellon Institute, Pittsburgh, Pa.).
Vey, William G., 12 Carlton St., Morristown, N. J. (902 Paul St., Ottawa, Ill.)
Westendick, Frank C., 1231 Wellman, S. E., Massillon, Ohio. (Alfred, N. Y.)
Williams, Ira C., U. S. Aluminum Co., Wear-Ever Building, New Kensington, Pa. (307 Lamar Ave., Maryville, Tenn.)

REFRACTORIES DIVISION, AMERICAN CERAMIC SOCIETY

Fall Meeting Program

The program for the Fall Meeting of the Refractories Division, AMERICAN CERAMIC SOCIETY and American Refractories Institute, is to be held at the Deshler-Wallick Hotel, Columbus, Ohio, Sept. 24–25, 1929. The Technical session is scheduled for September 24 and will start at 10:00 A.M. and 2:00 P.M.

The following program will be offered:

(1) "Fire Clays of Kentucky," by W. R. Jillson, State Geologist, Frankfort, Ky.
(2) "Fire Clays of Pennsylvania," by Henry Leighton, University of Pittsburgh, Pittsburgh, Pa.
(3) "Fire Clays of Ohio," by Wilber Stout, State Geologist, Columbus, Ohio.
(4) "Fire Clays of Saskatchewan," by G. M. Hutt, Canadian Pacific Railway Co., Montreal, Canada.
(5) "Mine Operation Problems," by H. E. Nold, Ohio State University, Columbus, Ohio.
(6) "Development of Clay Lands from Prospecting Data," by W. R. Chedsey, Pennsylvania State College, State College, Pa.
(7) "Clay Mining by Machine," Jeffrey Manufacturing Co., Columbus, Ohio.

The first four papers are dealing with the geological and geographical location of the fire clays. The last three papers deal with the practical problems of clay mining and development; also the economic phases will be taken into consideration. It is the belief of the Committee that the papers offered will be of keen interest to the technical men, operators, and executives.

NOTES AND NEWS

CERAMIC SCHOOL NOTES

Iowa State College

The Department of Ceramic Engineering at Iowa State College has had Dr. G. E. Cunningham appointed to the position of Assistant Professor. Dr. Cunningham will also serve as ceramic research chemist on the staff of the Engineering Experiment Station.

Dr. Cunningham took his undergraduate work at Tulane University, and while working for his M.S. there, was a student assistant in the Department of Chemistry. He then took his Ph.D. under Dr. Harry B. Weiser, of Rice Institute, working on colloid phenomena. He has been a professor in the chemistry department at Macalester College in St. Paul, Minnesota, this past year, and has taught chemistry also at Shorter College, in Rome, Ga. He has held a research fellowship at Cornell University during this summer, working on glass.

Dr. Cunningham expects to become a ceramist as a result of his work with the older members of the faculty and he was added to develop research work, primarily.

Professors Moulton and Cox and Design Professor Mary Yancey will continue as before. Professors Yancey and Moulton were given promotions in rank and pay in recognition of their success.

The Department of Ceramic Engineering at Iowa State College is having the plant completely changed this summer, with a two-story addition, a paved yard for stores, large storage bunkers added, some useless halls closed into the quarters thus increasing useful floor space. Partitions are being removed so that each laboratory will be double its old size. A large laboratory is being added to the department which has heretofore been used by the Mining Engineering Department.

A suite of five offices provides comfort for the faculty and the better arrangement of floor space provides for room for the needed machines and several new kilns and furnaces. One laboratory will be devoted solely to work in drier study. The total cost of the work will amount to about $10,000 with the equipment yet to be bought.

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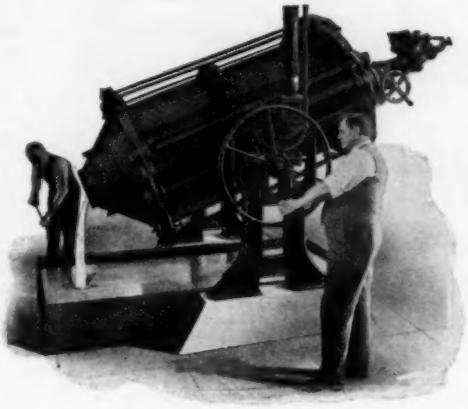

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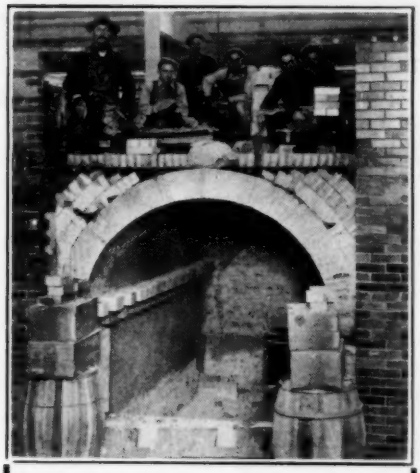

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- STILTS
- THIMBLES
- SPURS
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- CRUCIBLES
- TILE for Decorating Kilns

We Sell—

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- GROUND FIRE CLAY
- BITSTONE
- FIRE BRICK
- IMPORTED PARIS WHITE
- DOMESTIC WHITING

THE POTTERS SUPPLY COMPANY

EAST LIVERPOOL, OHIO

BUYERS' GUIDE (continued)

Colors
Drakenfeld and Co., B. F.
Harshaw Chemical Co.
Hommel Co., O.
Roessler and Hasslacher Chemical Co.
Vitro Mfg. Co.

Combustion Apparatus
Leeds & Northrup Co.

Conditioning Machinery
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.

Cones (Filter)
Norton Co.

Controllers
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.

Conveyers (Clay, Sand, Brick, etc.)
Mueller Machine Co., Inc.
Philadelphia Drying Machinery Co.

Cores (Alundum Furnace)
Norton Co.

Cornwall Stone
Eureka Flint & Spar Co.
Golding Sons Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
Pennsylvania Pulverizing Co.
Roessler and Hasslacher Chemical Co.

Cornwall Stone (Imported)
Golding Sons Company
Harshaw Chemical Co.

Crucibles (Filter, Melting, Ignition)
Norton Co.
Potters Supply Co.

Crushers
Chambers Brothers Co.
Mueller Machine Co., Inc.

Cryolite
Harshaw Chemical Co.
Roessler & Hasslacher Chemical Co.

D

Decorating Supplies
Drakenfeld and Co., B. F.
Harshaw Chemical Co.
Roessler and Hasslacher Chemical Co.
Vitro Mfg. Co.

Dishes (Alundum, Filtering, Ignition)
Norton Co.

Disintegrators
Chambers Brothers Co.
Mueller Machine Co., Inc.

Disks (Alundum, Porous, Filter)
Norton Co.

Dolomite
Harshaw Chemical Co.

Driers
Harrop Ceramic Service Co.

Driers (China Ware, Porcelain)
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.

Drying Machinery
Philadelphia Drying Machinery Co.
Proctor & Schwartz, Inc.

E

Electrical Instruments
Brown Instrument Co.
Leeds & Northrup Co.

Electrical Porcelain Machinery
Mueller Machine Co., Inc.

Enameling Equipment, Complete
Chicago Vitreous Enamel Product Co.
Ferro Enamel Supply Co.

Enameling Furnaces
Carborundum Co. (*Carboradiant*)
Chicago Vitreous Enamel Product Co.
Corundite Refractories Co.
Ferro Enamel Supply Co.
U. S. Smelting Furnace Co.
Vitro Mfg. Co.

Enameling Muffles
Carborundum Co. (*Carbofrax*)

Enameling, Practical Service
Chicago Vitreous Enamel Product Co.
Ferro Enamel Supply Co.
Vitro Mfg. Co.

Enamels
Harshaw Chemical Co.
Roessler & Hasslacher Chemical Co.

Enamels, Porcelain
Chicago Vitreous Enamel Product Co.
Ferro Enamel Supply Co.
Vitro Mfg. Co.

Engineering Service
Chambers Brothers Co.
Harrop Ceramic Service Co.

PENNSYLVANIA PULVERIZING CO.
LEWISTOWN, PA.

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BUYERS' GUIDE (continued)

Equipment (Porcelain Enameling)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Supply Co.

Exolon (Refractory Products)
The Exolon Co.

Extruding Machines (Lab. Use)
Chambers Brothers Co.

F

Fans
Philadelphia Drying Machinery Co.

Feldspar
Consolidated Feldspar Corp.
Erwin Feldspar Co.
Eureka Flint & Spar Co.
Golding-Keene Co.
Golding Sons Co.
Harshaw Chemical Co.
Pennsylvania Pulverizing Co.
Roessler and Hasslacher Chemical Co.
Southern Feldspar, Inc.
Standard Flint & Spar Co.
United Feldspar Corp.

Filter Cloth (Wire)
W. S. Tyler Co.

Filtering Machinery
Mueller Machine Co., Inc.

Fire Brick
Carborundum Co.
Corundite Refractories Co.
Harbison-Walker Refractories Co.

Flint
Eureka-Flint & Spar Co.
Golding Keene Co.
Golding Sons Co.
Harshaw Chemical Co.
National Silica Co.
Pennsylvania Pulverizing Co.
Roessler and Hasslacher Chemical Co.
Southern Feldspar, Inc.
Standard Flint & Spar Co.

Flint (American Sand and Rock)
Golding Sons Company

Flint (Imported French)
Golding Sons Company

Flint Pebbles
Eureka Flint & Spar Co.
Golding Sons Co.
Harshaw Chemical Co.
Roessler & Hasslacher Chemical Co.

Flow Meters
Brown Instrument Co.
Leeds & Northrup Co.

Frit
Vitro Mfg. Co.

Furnaces
Carborundum Co. (*Carboradiant*)
Chicago Vitreous Enamel Product Co.
Corundite Refractories Co.
Ferro Enamel Supply Co.
Harrop Ceramic Service Co.
U. S. Smelting Furnace Co.

Furnaces (Electrical Laboratory Type)
Engelhard, Chas., Inc.

Furnace Slabs
Corundite Refractories Co.

G

Glaze and Body Spar
Consolidated Feldspar Corp.
Golding Sons Company
Harshaw Chemical Co.

Glazes and Enamels
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Ferro Enamel Supply Co.
Harshaw Chemical Co.
Roessler and Hasslacher Chemical Co.
Vitro Mfg. Co.

Glaze Spar
Consolidated Feldspar Corp.
Erwin Feldspar Co.
Eureka Flint & Spar Co.
Golding Sons Co.
Harshaw Chemical Co.
Roessler & Hasslacher Chemical Co.

Gold
Drakenfeld & Co., B. F.
Harshaw Chemical Co.
Roessler and Hasslacher Chemical Co.
Vitro Mfg. Co.

Guards (Safety)
W. S. Tyler Co.

H

Hearths
Carborundum Co.
(*Carbofrax* heat treating)

Hearths (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.

Humidity Control
Brown Instrument Co.
Leeds & Northrup Co.

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Established 1914

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Finishing Plant, General Offices { **BLASDELL, N. Y.**

BUYERS' GUIDE (continued)

Hydrogen Ion Equipment
Leeds & Northrup Co.

Hygrometers
Brown Instrument Co.

I

Indicators & Recorders (Steam, Air, Gas)
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.

Indicators, Chemical
Leeds & Northrup Co.

Infusorial Earth
Harrop Ceramic Service Co.

Instruments (Temperature, Pressure)
Brown Instrument Co.
Leeds & Northrup Co.

Iron (Enameling)
American Rolling Mill Co.

J

Jiggers
Mueller Machine Co., Inc.

K

Kaolin
Edgar Brothers Co.
Golding Sons Co.
Harshaw Chemical Co.
Roessler and Hasslacher Chemical Co.
United Clay Mines Corp.

Kaolin (Delaware)
Golding Sons Company

Kilns
Harrop Ceramic Service Co.

Kilns (China, Decorating)
Drakenfeld & Co., B. F.

Kryolith
Harshaw Chemical Co.
Pennsylvania Salt Mfg. Co.
Roessler and Hasslacher Chemical Co.

L

Laboratory Supplies
W. S. Tyler Co.

Lawn
W. S. Tyler Co.

Leers (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.

Linings (Furnace Refractory, Block Refractory Plate, Brick and Tile)
Carborundum Co.
Corundite Refractories Co.
Harbison-Walker Refractories Co.
Norton Co.

Liquid Level Indicator and Recorder
Brown Instrument Co.
Leeds & Northrup Co.

M

Magnesia (Sintered, Calcined)
The Exolon Co.
Harbison-Walker Refractories Co.
Roessler & Hasslacher Chemical Co.

Magnesite
Drakenfeld & Co., B. F.
Harbison-Walker Refractories Co.
Harshaw Chemical Co.
Roessler & Hasslacher Chemical Co.

Manganese
Drakenfeld & Co., B. F.
Harshaw Chemical Co.
Roessler and Hasslacher Chemical Co.

Manometers
Brown Instrument Co.

Metals (Porcelain Enameling)
American Rolling Mill Co.

Meters (All Kinds)
Brown Instrument Co.
Engelhard, Chas., Inc.

Microscope
Bausch & Lomb Optical Co.

Minerals
Drakenfeld & Co., B. F.
Erwin Feldspar Co.
Golding Sons Co.
Harshaw Chemical Co.
Roessler and Hasslacher Chemical Co.
Vitro Mfg. Co.

Mixing Machines
Chambers Brothers Co.

Motors
Harrop Ceramic Service Co.

Muffles (Furnace)
Carborundum Co. (*Carbofrax*)
Corundite Refractories Co.
Norton Co.

Mullite (Artificial)
The Exolon Co.

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MONTGOMERY PORCELAIN PRODUCTS CO.

FRANKLIN, OHIO, U. S. A.

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Crushers Grinders Mixers

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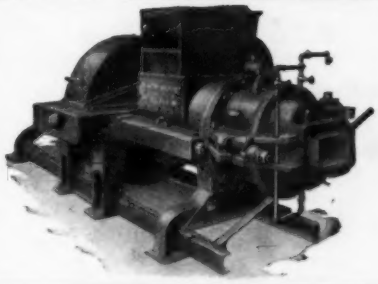

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INCORPORATED

Trenton-New Jersey

BUYERS' GUIDE (continued)

Muriatic Acid
Harshaw Chemical Co.
Pennsylvania Salt Mfg. Co.
Roessler and Hasslacher Chemical Co

N

Nitrates (Cobalt, Sodium)
Harshaw Chemical Co.
Roessler & Hasslacher Chemical Co.

O

Opacifiers
Harshaw Chemical Co.
Hommel Co., O.
Titanium Alloy Mfg. Co.

Orifice Plates
Brown Instrument Co.

Oxides
Drakenfeld & Co., B. F.
Harshaw Chemical Co.
Hommel Co., O.
Metal & Thermit Corp.
Pennsylvania Salt Mfg. Co.
Roessler and Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
Vitro Mfg. Co.

P

Pans (Wet and Dry)
Chambers Brothers Co.
Mueller Machine Co., Inc.

Pebble Mills
Abbé, Paul O.
Mueller Machine Co., Inc.

Petrographic Microscope
Bausch & Lomb Optical Co.

Pins
Potters Supply Co.

Placing Sand
Eureka Flint & Spar Co.
Golding Sons Co.
National Silica Co.
Pennsylvania Pulverizing Co.
Roessler & Hasslacher Chemical Co.
United Clay Mines Corp.

Plant Design
Harrop Ceramic Service Co.

Plate Feeders
Chambers Brothers Co.

Plate (Filter)
Norton Co.

Porcelain Enameling Service, Practical
Chicago Vitreous Enamel Product Co.
Ferro Enamel Supply Co.
Vitro Mfg. Co.

Porcelain Enamels
Chicago Vitreous Enamel Product Co.
Ferro Enamel Supply Co.
Roessler & Hasslacher Chemical Co.
Vitro Mfg. Co.

Potash (Carbonate)
Harshaw Chemical Co.
Roessler & Hasslacher Chemical Co.

Potassium Bi-fluoride
Harshaw Chemical Co.
Roessler & Hasslacher Chemical Co.

Pottery Machinery
Mueller Machine Co., Inc.

Pug Mills
Chambers Brothers Co.
Mueller Machine Co., Inc.

Pulverizing Machinery
Abbé, Paul O.
Mueller Machine Co., Inc.

Pulverizing Mills
Abbé, Paul O.
Mueller Machine Co., Inc.

Pumps
Mueller Machine Co., Inc.

Pyrometers (Indicating)
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.

Pyrometers (Optical)
Leeds & Northrup Co.

Pyrometers (Recording)
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.

Pyrometer (Switches)
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.

Pyrometer Thermocouples
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.

Pyrometer Tubes (Refractory and Hard Porcelain)
Brown Instrument Co.
Corundite Refractories Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.
McDanel Refractory Porcelain Co.
Montgomery Porcelain Products Co.

R

Recorders (CO, CO_2, SO_2 and Draft)
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.

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Cobalt—Copper
Zirconium—Selenium
Selenite of Sodium
Sulphide of Cadmium
Antimonate of Sodium

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Chicago Vitreous Enamel Product Co.

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BUYERS' GUIDE

correct?

If

YOU

desire additional listings, do not hesitate to write us.

BUYERS' GUIDE (continued)

Recording Instruments
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.

Refractories
Carborundum Co.
Corundite Refractories Co.
The Exolon Co.
Harbison-Walker Refractories Co.
Norton Co.
United Clay Mines Corp.

Refractory Materials
The Exolon Co.
Golding Sons Co.
Harbison-Walker Refractories Co.
United Clay Mines Corp.

Regulators (Automatic Temperature)
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.

Rutile
Titanium Alloy Mfg. Co.

S

Sagger Clay (Georgia)
Golding Sons Company

Sagger Presses
Chambers Brothers Co.
Mueller Machine Co., Inc.

Saggers
Carborundum Co.
Norton Co.
Potters Supply Co.

Screening Machinery
W. S. Tyler Co.

Screens (Cloth, Electric Vibrating)
W. S. Tyler Co.

Selenite of Sodium
Drakenfeld & Co., B. F.
Harshaw Chemical Co.
Vitro Mfg. Co.

Selenium
Drakenfeld & Co., B. F.
Harshaw Chemical Co.
Roessler & Hasslacher Chemical Co.

Separators (Inclined Vibrating)
W. S. Tyler Co.

Shakers (Testing Sieve)
W. S. Tyler Co.

Sieves (Testing)
W. S. Tyler Co.

Silica Blocks
Eureka Flint & Spar Co.
Golding Sons Co.

Silica (Fused)
The Exolon Co.

Silicon Carbide
The Exolon Co.

Silicon Carbide Firesand
The Exolon Co.

Sillimanite (Synthetic)
The Exolon Co.
Harshaw Chemical Co.
Norton Co.

Slabs (Furnace)
Carborundum Co.
Norton Co.

Smelters
Chicago Vitreous Enamel Product Co.
U. S. Smelting Furnace Co.

Soda Ash
Harshaw Chemical Co.
Roessler and Hasslacher Chemical Co.

Sodium Antimonate
Harshaw Chemical Co.
Metal & Thermit Corp.
Roessler and Hasslacher Chemical Co.
Vitro Mfg. Co.

Sodium Fluoride
Harshaw Chemical Co.
Roessler and Hasslacher Chemical Co.

Spar
Erwin Feldspar Co.
Golding Sons Co.
Harshaw Chemical Co.
Pennsylvania Pulverizing Co.
Roessler and Hasslacher Chemical Co.

Spurs
Potters Supply Co.

Stilts
Potters Supply Co.

Sulphuric Acid
Drakenfeld & Co., B. F.
Harshaw Chemical Co.
Pennsylvania Salt Mfg. Co.
Roessler and Hasslacher Chemical Co.

T

Tachometers
Brown Instrument Co.
Leeds & Northrup Co.

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PURE
GREENLAND KRYOLITH
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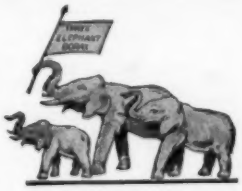
99.5% PURE

Its uniform high quality guarantees the excellence of your product.

We also make Boric Acid Guaranteed 99.5% pure. Write for our price and samples today.



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Woolworth Building, New York, N. Y.

HIGH GRADE
CLAYS
OF EVERY KIND-FOR EVERY PURPOSE
UNITED CLAY MINES
CORPORATION
GENERAL OFFICES TRENTON, N.J.

BUYERS' GUIDE (continued)

Talc
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
Old Hickory Clay & Talc Co.
Roessler and Hasslacher Chemical Co.

Temperature Controls
Engelhard, Chas., Inc.
Leeds & Northrup Co.

Temperature Instruments (Measuring)
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.

Thermocouples
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.

Thermometers (Electric Resistance, Indicating, etc.)
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.

Thimbles (Filtering Extraction)
Norton Co.

Tile Machinery (Floor and Wall)
Mueller Machine Co., Inc.

Tile (Refractory)
Carborundum Co. (*Carbofrax*)
Harbison-Walker Refractories Co.

Tin Oxide
Drakenfeld & Co., B. F.
Harshaw Chemical Co.
Metal & Thermit Corp.
Roessler and Hasslacher Chemical Co.

Titanium
Harshaw Chemical Co.
Titanium Alloy Mfg. Co.

Tubes (Insulating)
McDanel Refractory Porcelain Co.
Montgomery Porcelain Products Co.

Tubes (Pyrometer)
Brown Instrument Co.
Engelhard, Chas., Inc.
Leeds & Northrup Co.
McDanel Refractory Porcelain Co.
Montgomery Porcelain Products Co.

V

Vacuum Pumps
Mueller Machine Co., Inc.

Valves (Automatic Control)
Brown Instrument Co.
Engelhard, Chas., Inc.

Vibrating Screens
W. S. Tyler Co.

V-Notch Meters
Brown Instrument Co.

W

Wet Enamel
Chicago Vitreous Enamel Product Co.
Vitro Mfg. Co.

Whiting
Drakenfeld & Co., B. F.
Harshaw Chemical Co.
Roessler and Hasslacher Chemical Co.

Wire Cloth
W. S. Tyler Co.

Witherite
Harshaw Chemical Co.

Woven Wire
W. S. Tyler Co.

Z

Zirconia
Harshaw Chemical Co.
Roessler and Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
Vitro Mfg. Co.

PARIS TOP WHITE
JERNIGAN BALL
BLACK & TAN WAD

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Branch Office: 504 Distributors Bldg., Chicago, Ill.

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GOLDING-KEENE COMPANY
KEENE, NEW HAMPSHIRE

THE STANDARD FLINT & SPAR CORP.
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Profile Notch,
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TOECANE, NO. CAROLINA

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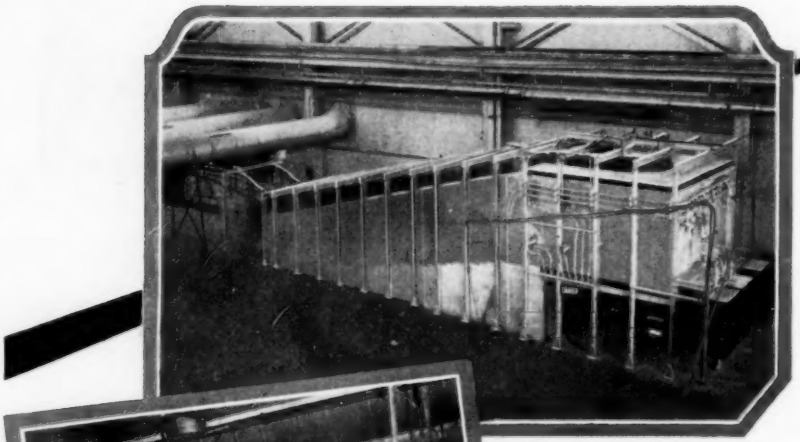
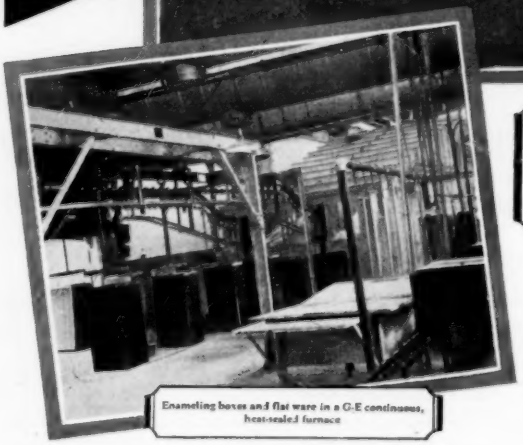
Every Large Enameling Plant





Enameling boxes and flat ware in a G-E continuous, heat-sealed furnace

It isn't the cost of repairs that worries an enameler when his furnace breaks down—it's the very serious loss of production. The General Electric continuous, heat-sealed enameling furnace assures continuity of operation because it is one of the most dependable pieces of equipment built. If this were not so, General Electric would not be using 12 of these furnaces in producing its refrigerators—a field of manufacture where continuity of operation is all important.

Investigate Electric Heat!

GENERAL

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

Can Now Afford Electric Heat
... with this new furnace

ENAMELERS have long agreed that electric heat was the ideal heat for firing enamel but they usually hesitated to install an electric furnace, because they believed the cost of operation was prohibitive.

To-day, General Electric representatives are kept continually on the jump answering the requests of enamelers for personal explanations of the new G-E continuous enameling furnace with heat-sealed firing chamber—the furnace that made electric enameling economical.

In a recent 8-hour test, one of these furnaces produced 5,000 sq. ft. of finished white coat at an average gross *economy of 16 lb. per kw-hr.

This is simply the firing cost, and does not take into consideration the reduction in handling charges (which in some installations has amounted to 66%); the improvement in the quality of the enamel—freedom from warpage; greater toughness, greater uniformity; the greatly reduced maintenance cost; the freedom from costly shutdowns; and all the intangible advantages of electric heat which combine to lower over-all costs.

The number of these furnaces, now in operation or under construction, has increased to 22. Even though you are not ready to purchase now, you should have the facts. There is a heating specialist in your vicinity who will give you these facts. Simply ask your nearest G-E office.

*Including tools

ELECTRIC HEAT
is cheaper than Shutdowns

570-106 D

ELECTRIC
SALES OFFICES IN PRINCIPAL CITIES

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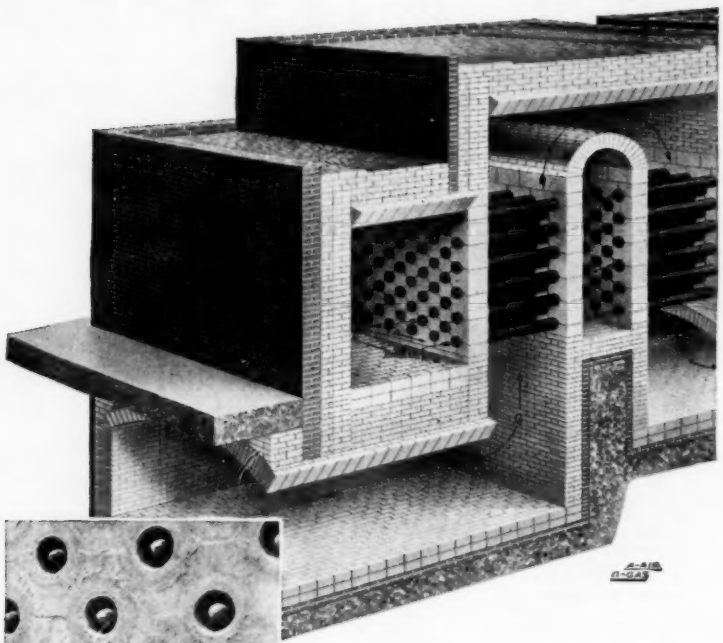

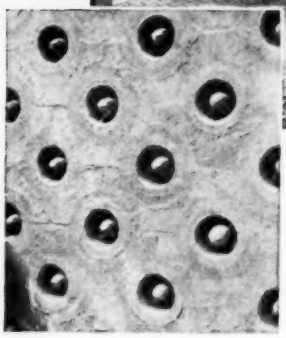

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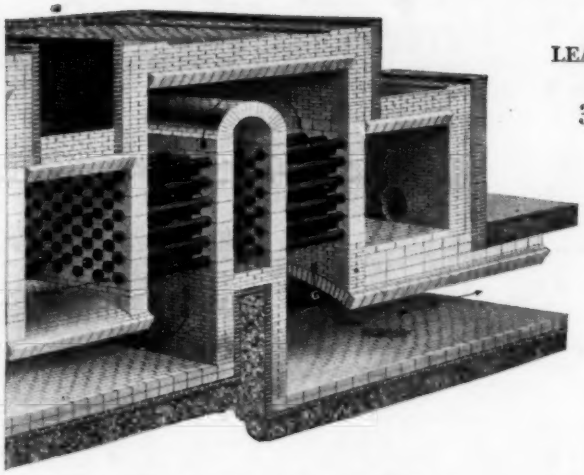

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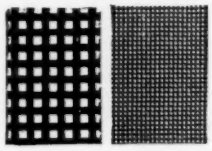
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